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DEMONSTRATION ADVANCED AVIONICS SYSTEM (DAAS) FUNCTIONAL DESCRIPTION

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Table of Contents

Table of Contents (Concluded)

List of Illustrations

List of Illustrations (Continued)

List of Illustrations (Concluded)

List of Tables

Section 1.0
Introduction

The Demonstration Advanced Avionics System (DAAS) integrates a comprehensive set of general aviation avionics functions into an advanced hardware mechanization for demonstration in a Cessna 402B aircraft. This document presents a functional definition of DAAS. The emphasis is on description of function rather than implementation.

Major Sections of the document are:

- DAAS System Description — This section contains block diagrams, descriptions of system and computer architecture and describes significant hardware elements.
- Multifunction Controls and Displays — The DAAS multifunction Integrated Data Control Center (IDCC) and Electronic Horizontal Situation Indicator (EHSI) are described.
- DAAS System Functions — This section describes the functions that the DAAS will perform. It is organized by function.

This functional definition is the basis for the DAAS hardware and software design.

Section 2.0
DAAS System Concept

Several years ago the NASA Ames Research Center initiated a program to improve avionics for general aviation by applying, whenever possible, new developments in computing and sensing devices. The overall objective was to improve the safety and dependability (schedule adherence) of general aviation IFR operations **without** increasing the required pilot training/experience by **exploiting advanced technology** in computers, displays and system design. Earlier studies in the program provided a data base in computer technology potential, air traffic control environment, and system configuration possibilities. These studies also indicated that to bring advanced avionics benefits to general aviation at an affordable price, changes should not merely be those of improving existing devices and adding a few new "aids" to an already crowded cockpit; but should take the form of a rather sweeping change in the approach to combining sensors, computers and displays into systems which will meet the overall objective. The current Demonstration Advance Avionics System (DAAS) is the culmination of this effort and is intended to demonstrate the feasability of the approach by designing, building and flying a set of demonstration equipment.

Section 3.0
DAAS System Description

The DAAS is an integrated system. It performs a broad range of general aviation avionics functions using one computer system, and shared controls and displays.

This section introduces the DAAS function set, and describes the system architecture and its components to provide background for the detailed function definition of subsequent sections.

3.1 DAAS FUNCTIONS

DAAS Functions include:

- Autopilot
  - Yaw Damper
  - HDG SEL (Heading Select)
  - ALT, ALT ARM (Altitude Hold, Altitude Arm)
  - NAV, VNAV Coupled Control
  - Approach Coupled Control

- Navigation/Flight Planning
  - VOR, VOR/DME Radio Navigation
  - 10 Waypoints, 10 NAVAID Storage
  - Kalman Filter Blending
  - Moving Map Display

- VNAV (Vertical Navigation)

- Flight Warning/Advisory System
  - Engine Parameter Monitoring Warning
  - Aircraft Configuration Monitoring, Warning
  - Airspeed and Stall Monitoring, Warning
  - Altitude Advisory Function
  - Marker Beacon Advisory Function
  - NAVAID Identification Monitoring
  - Autopilot/Flight Director
  - BIT Fault Warning

- GMT Clock Function

- Fuel Totalizer Function

- Weight and Balance Computations

- Performance Computations
  - Takeoff Performance
  - Cruise Performance
  - Fuel/Distance/Time Computation

- DABS (Discrete Address Beacon System) ATC Communication, Weather Reporting
- BIT (Built in Test)

- Normal, Emergency Checklists

The autopilot is a digital version of the King KFC 200 modified for compatibility with DAAS. The navigation/flight planning function computes aircraft position with respect to an entered flight plan, and blends dead-reckoning position (as determined from airspeed and heading) with position extracted from automatically tuned VOR/DME receivers.

DAAS includes extensive monitoring, with warning capability. For example, the DAAS system monitors engine performance (MAP, RPM), aircraft configuration (gear position, flap position, etc.) with respect to flight condition, and ground proximity and informs the pilot of undesirable situations.

The DAAS computer serves as a GMT clock.

Fuel flow is integrated to totalize fuel used.

Weight and balance, and takeoff cruise performance calculations can be quickly and conveniently performed using DAAS controls and displays.

The DAAS system will determine fuel and time required to fly specific segment distances given altitude, temperature, wind data, and engine power setting.

ATC text messages (e.g., CLIMB AND MAINTAIN 12000 FT) or weather information at destination can be communicated to the DAAS pilot via DADS data link and displayed on the DAAS electronic display.

The DAAS system will detect and localize its own faults via BIT. Provisions are also included for troubleshooting the DAAS hardware through DAAS controls and electronic displays.

Normal and emergency checklists are stored in the DAAS computer, and are available for display at the push of a button.

These functions are managed via shared controls and displays, and performed in the common DAAS computer system.

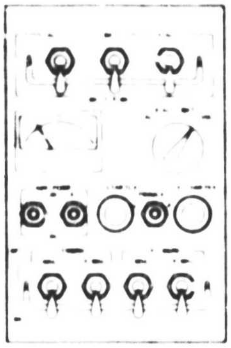
Following is an introduction to the DAAS controls and displays, computer system architecture, and a description of DAAS major subsystems.

3.2 DAAS CONTROLS AND DISPLAYS — GENERAL

The DAAS Cessna 402B aircraft contains:

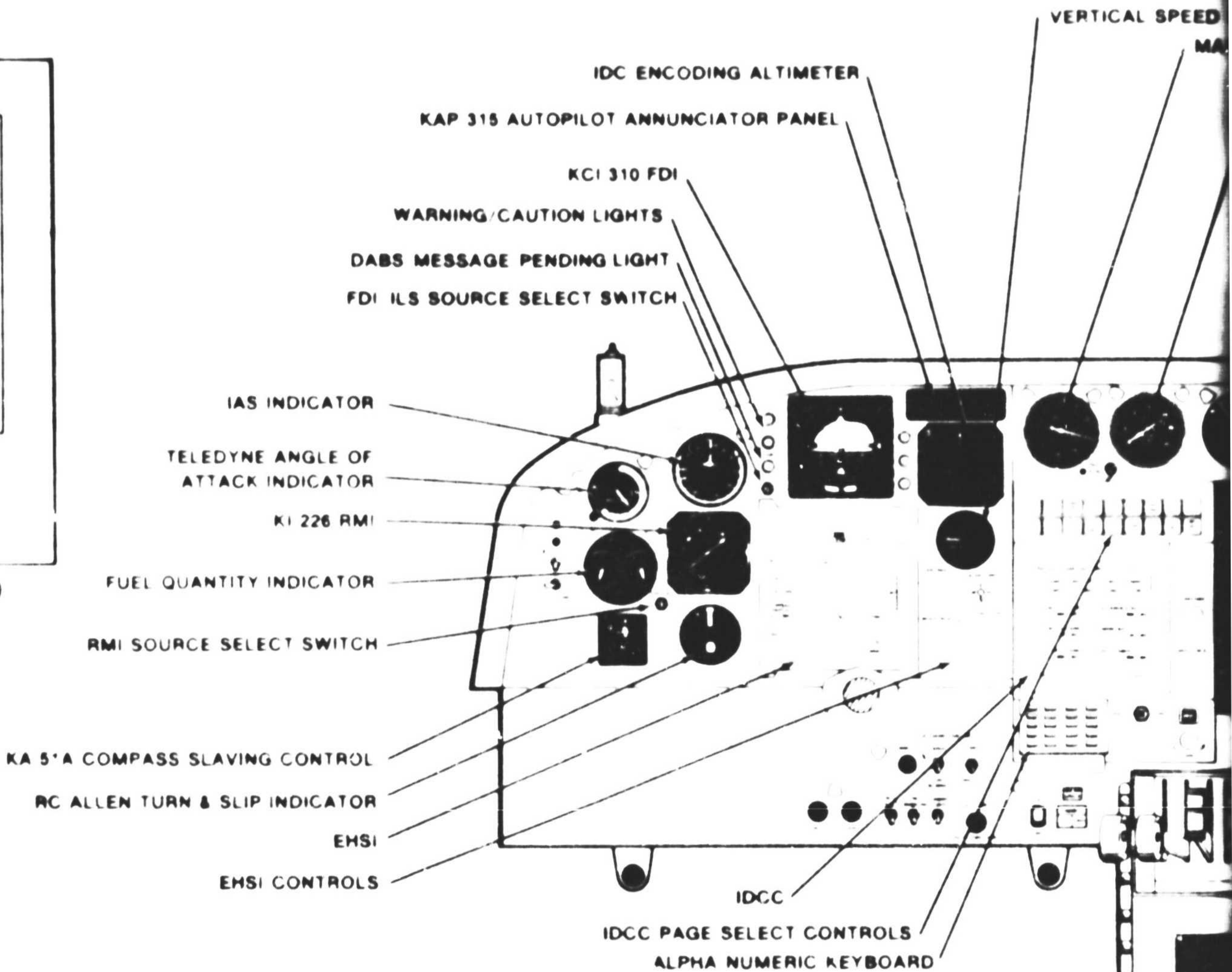
- Controls and displays necessary to manage DAAS functions.
- Additional instruments necessary for IFR flight operations.
- Independent safety pilot instrument installation.

These controls and displays are layed out in the 402B control panel as indicated in Figure 1., Cessna 402B Panel Layout. DAAS pilot is in the left seat, and the safety pilot is the right seat. Electronic displays — the Electronic Horizontal Situation Indicator (EHSI) and Integrated Data Control Center (IDCC) — are key elements of the panel.

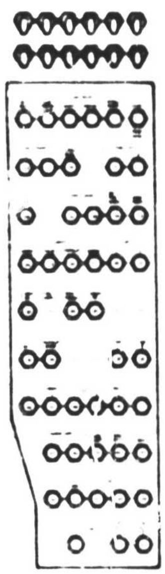


OVERHEAD CONTROL PANEL

(See Figure 7)



DAAS PILOT PANEL



LEFT CIRCUIT BREAKER PANEL

(See Figure 7)

FOLDOUT FRAME

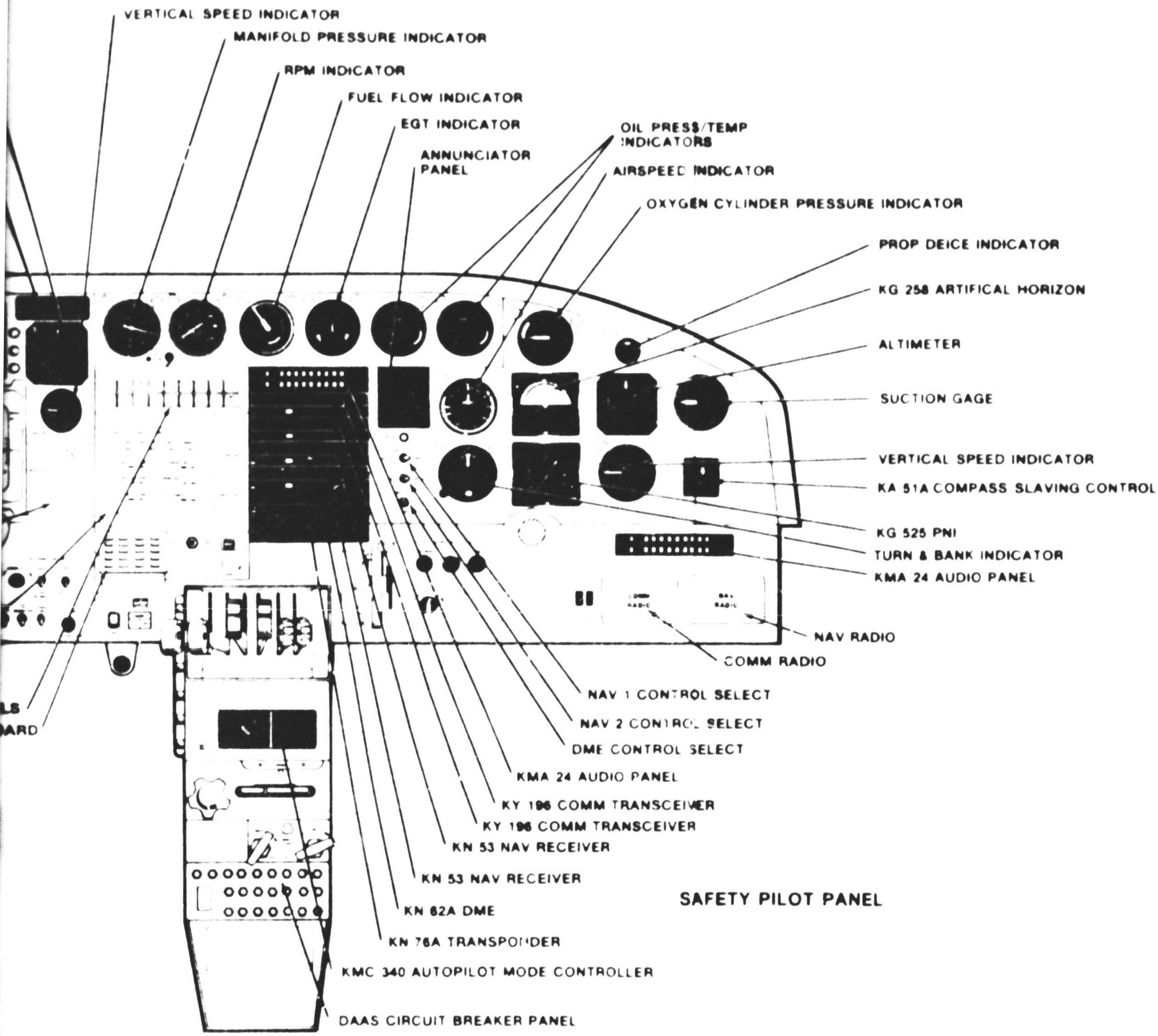


Figure 1. Cessna 402B Control Panel Layout

The EHSI presents a moving map display showing aircraft position with respect to desired course. The display is a 4.5-inch by 4.5-inch monochromatic Ball Brothers 103C CRT raster display unit. The display unit has 256- by 256-dot matrix display capability. P43 phosphor is used together with an appropriate narrow band optical filter to allow operation in bright sunlight. The EHSI is controlled by functional control buttons and a map slew controller.

The Integrated Data Control Center (IDCC) is the pilot's primary means of interacting with DAAS. Included are a keyboard at the bottom of the unit and a set of function buttons along the top. The function buttons include a set of page select buttons which determine the information that is displayed on the IDCC display.

The IDCC display CRT is identical to the EHSI, i.e., 4.5-inch by 4.5-inch Ball Brothers monochromatic unit. The IDCC can display 16 lines of 32 characters each. Line spacing is 0.25 inch, character height is 0.162 inch, and character width is 0.125 inch.

The IDCC is implemented with menu select buttons along each side of the CRT, or with a pressure sensitive plastic screen overlay for touch point menu selection. The alternate approaches can be implemented to allow comparison during flight test.

The DAAS EHSI is surrounded by the conventional "T" pattern of flight control instruments.

The ADI used in DAAS is the 4-inch King KCI 310 Flight Command Indicator.

The altimeter is an IDC Encoding Altimeter type 519-28702-571. An Altitute Alert light is mounted on the altimeter.

The rate-of-climb indicator provides vertical speed information to the pilot. The display presents rates of climb, or descent, in feet per minute. The face is 2-1/4 inches wide.

The King KI 226 RMI displays heading and bearing to a selected VOR station.

The DAAS Autopilot Mode Controller is located on the pedestal, and the Autopilot Mode Annunciator is located above the altimeter.

DAAS engine instruments and radio stack are centrally located and are accessible to the DAAS pilot and the safety pilot.

Unique DAAS switch controls located on the panel include:

- NAV 1-DAAS/MANUAL Tune (located to the right of the NAV 1 radio)
- NAV 2-DAAS/MANUAL Tune (located to the right of the NAV 2 radio)
- DME TRANSFER (located to the right of the DME)
- VOR source switch (located to the lower left of the RMI)
- ILS source switch (located to the lower left of the ADI)

NAV Receivers can be tuned manually (MANUAL) or automatically (DAAS). The DME transfer switch allows the DME receiver to be tuned by either NAV receiver 1 or 2. The DAAS position slaves the DME to the NAV receiver being controlled by DAAS.

The safety pilot instrument set is independent from the DAAS instruments, and adequate for safe flight with DAAS inoperative.

The safety pilot's Pictorial Navigation Indicator displays aircraft magnetic heading (gyro-stabilized), selected heading and selected course. Also, VOR and localizer course deviation, glideslope deviation and a TO-FROM indication are presented.

The safety pilot's KG-258 artificial horizon is an air driven unit. It is the safety pilot's basic attitude/horizon reference indicator.

Aircraft master power controls (see Figure 7) are centrally located overhead. Circuit breakers (see Figure 7) are located on the pedestal.

3.3 DAAS SYSTEM ARCHITECTURE

DAAS system architecture is presented in Figure 2. The architecture is characterized by a modular computer system structure; i.e., multimicroprocessors interconnected by an IEEE 488 data bus. Each processor block in Figure 1, except for the radio system, represents an Intel 8086 16-bit microprocessor, 2k by 16 PROM memory, and 4k by 16 to 16k by 16 RAM memory. The radio System uses the Intel 8048 microprocessor.

Each processor performs a function, and interfaces directly with the subsystems associated with that function. At power-on, the bus controller Central Computer (CC) CPU-1 takes functional programs from the nonvolatile bubble memory, and sequentially

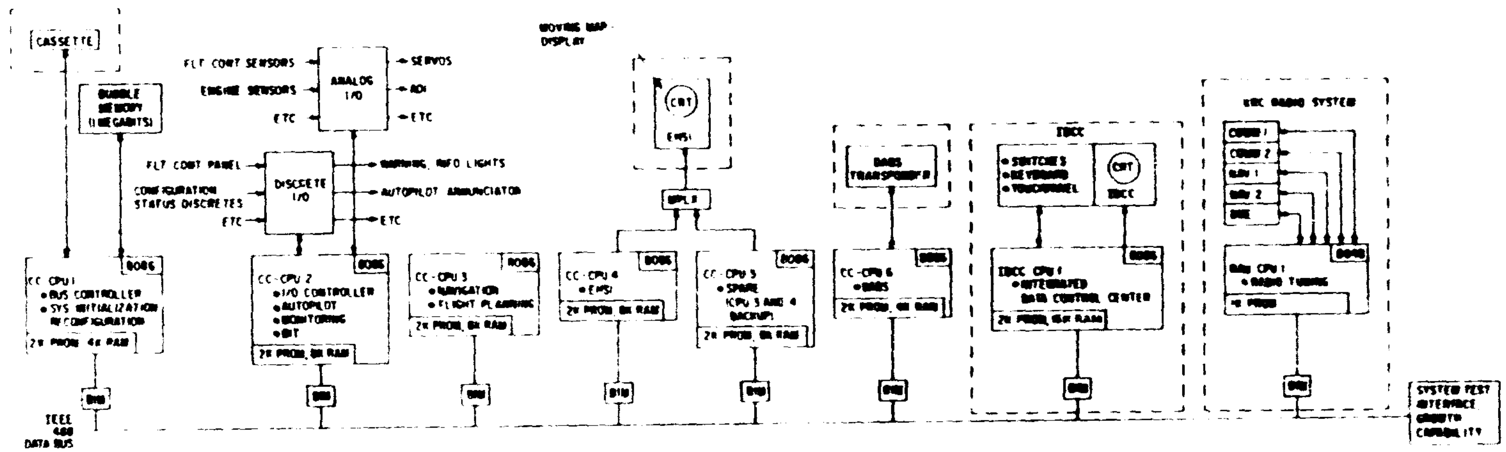


Figure 2. DAAS System Architecture

loads each processor at the rate of approximately 2 seconds per processor. When all processors are loaded, the bus controller activates the system. The bus controller then manages bus communications during normal operations.

A portable TI Silent 700 cassette unit can interface with the bus controller to allow load or modifications of the functional software.

CC-CPU 5 is a spare processor. If processor CC-CPU 3 or CC-CPU 4 fails and the bus controller detects the failure, the bus controller will load CC-CPU 5 with appropriate software from bubble memory, and CC-CPU 5 will take over the function of the failed processor. (Note: This reconfiguration capability is especially important when an EHSI and an EADI are included in the system.With a failure in one display, the spare processor can be loaded to allow time sharing of the remaining good display as both EADI and EHSI.) Such reconfiguration could be extended to other processors such as CC-CPU 2, the autopilot. However, for such reconfiguration the spare processor must interface with autopilot subsystems, which requires additional multiplexing of hardware. Reconfiguration was thus applied only to a limited degree in this demonstrator system.

The DAAS architecture is modular. Functions can be added by adding necessary standard processor modules onto the 488 data bus, and interfacing these processor modules with the devices associated with the new function.

Six processors are contained in the DAAS Central Computer Unit. One processor is contained in the IDCC, and one processor is contained in the radio adapter unit.

3.4 DAAS MAJOR SUBSYSTEMS

DAAS system components, and their interconnections are depicted in Figure 3, DAAS System Diagram. Interconnection between the DAAS panel instruments, sensors, and the DAAS computer system is shown. The DAAS Central Computer obtains data from the radio system (radio adapter unit, radio stack), flight control sensors, engine instruments, configuration status sensors, and IDCC. Functional computations are performed on the input data and the results applied to EHSI, FDI, warning/caution lights, and autopilot servos.

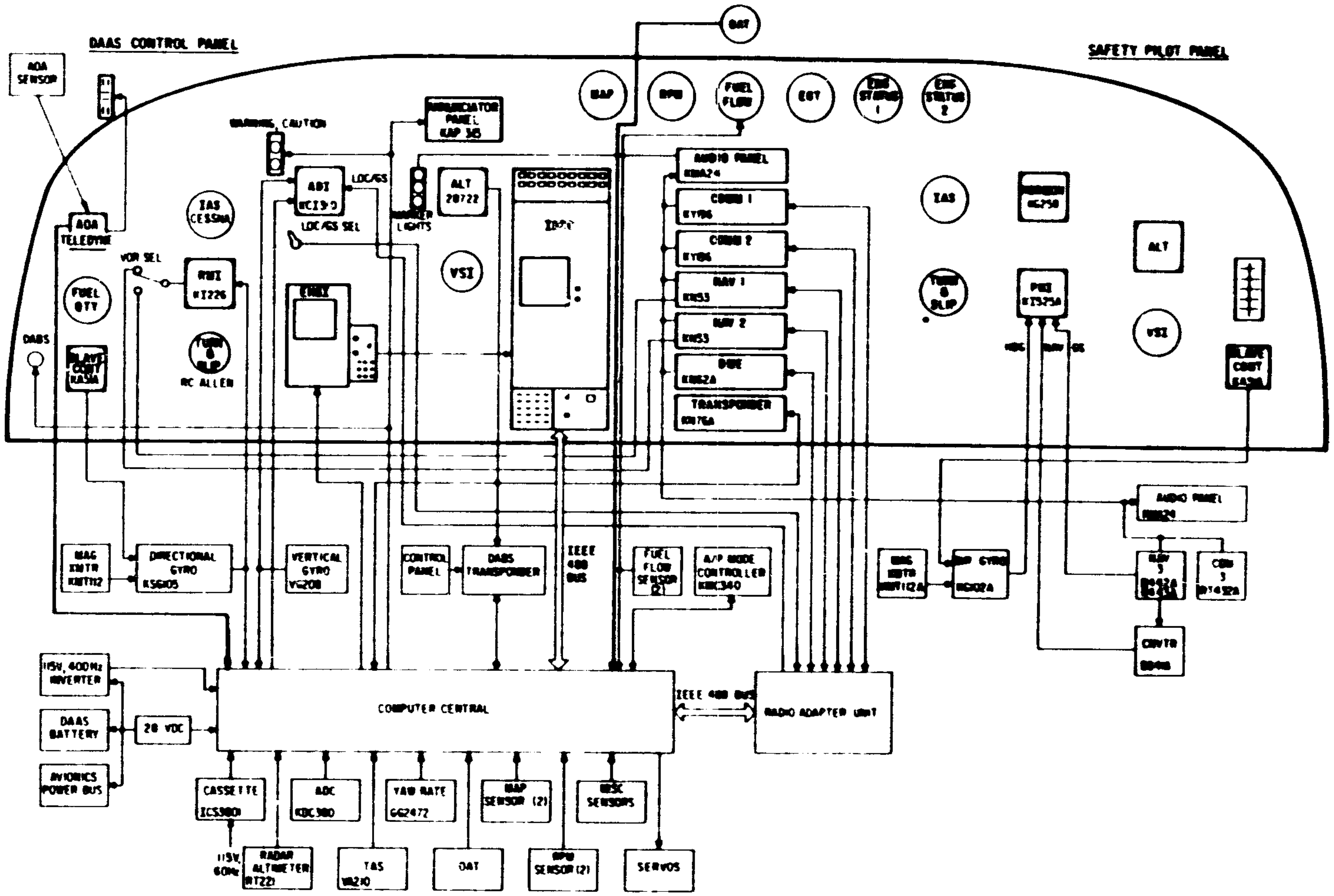


Figure 3. DAAS System Diagram

Following is a description of the DAAS major subsystems including:

- Central Computer Unit
- Radio System
- Flight Control Sensors, Servo Actuators
- Engine Sensors
- Configuration Monitor Sensors
- Miscellaneous Sensors
- DABS

Selected devices are depicted in Figure 4.

3.4.1 Central Computer Unit

The computer unit performs the functions of navigation, engine monitoring, flight control, weight and balance computations, performance computations and maintenance test

The computer unit contains six 16-bit, Intel 8086 Microprocessors interconnected through an IEEE 488 Data Bus System.

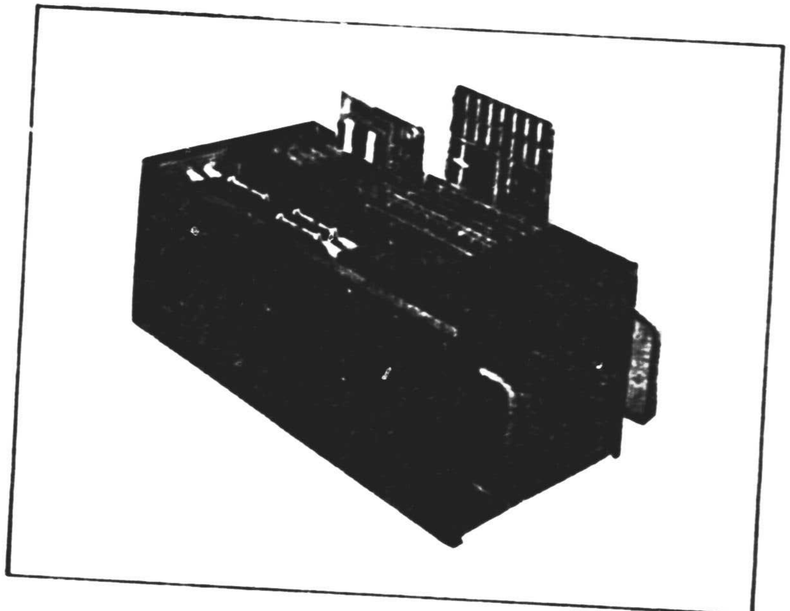
Following is description of Central Computer elements including:

- Processor
- Input/Output
- Bubble Memory System
- EHSI Display Controller
- Power Supplies

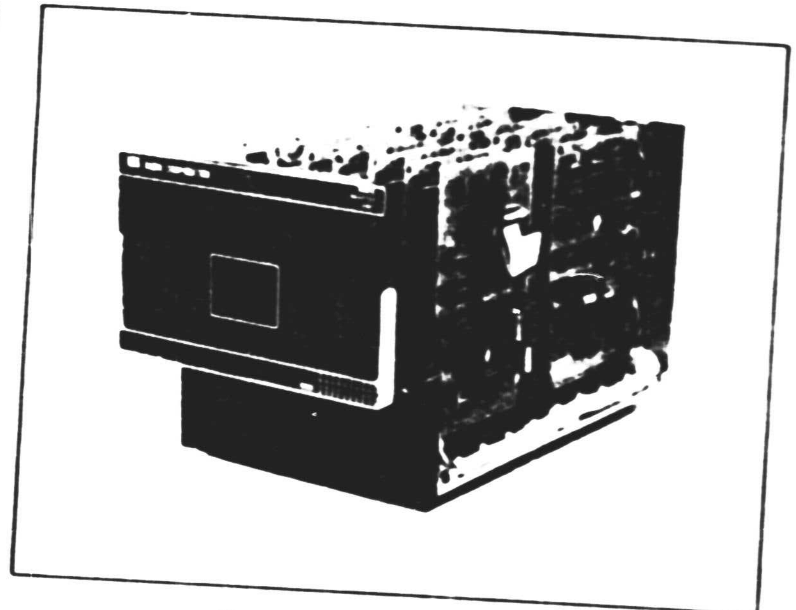
3.4.1.1 Central Computer Processor — The Central Computer processor, Figure 4, is designed to fit on a single subassembly. The 8086 Microprocessor, 4k RAM, 2k UV-EPROM, interrupt controller, clock, memory chip-select logic, bus-buffer logic, and 488 bus interface are included on this subassembly.

The Intel 8086 was selected for the computer unit microprocessor based on:

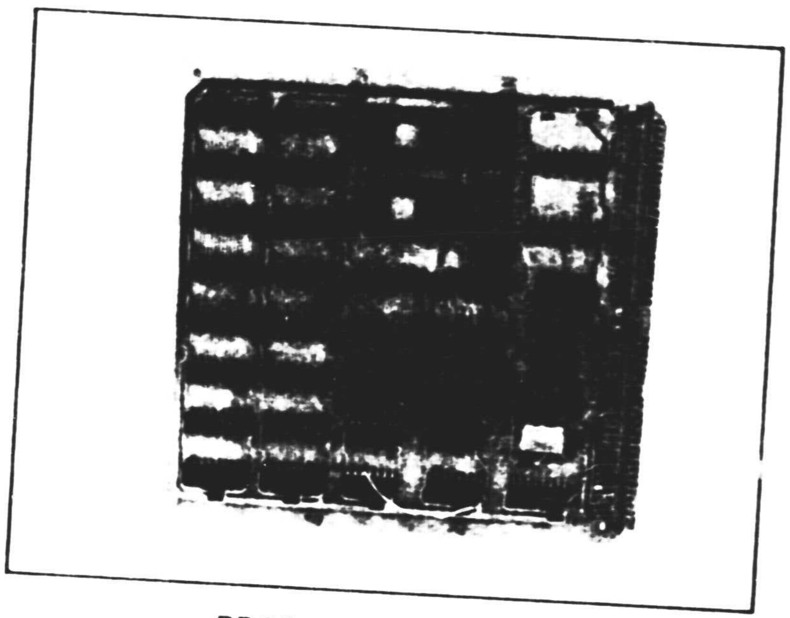
- Availability of the microprocessor
- Availability and cost of software development hardware and support software
- Microprocessor throughput capability
- Availability of High Order Language (HOL)



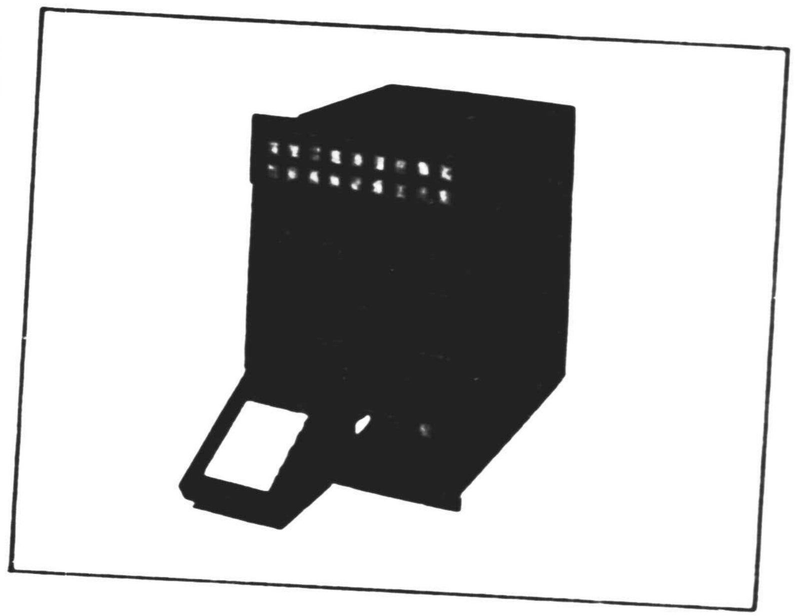
CENTRAL COMPUTER



RADIO ADAPTER UNIT



PROCESSOR MODULE



IDCC

Figure 4 DAAS System Hardware

8086 Processor hardware and software development support equipment were available when needed in mid-1979. The processor has adequate throughput, and a PLM higher order language compiler is available.

The 8086 is a 16-bit integer microcomputer. It contains four 16-bit index registers. The processor chip can address 1 megabyte of memory.

The H-MOS device is contained in a 40-pin dual in-line package.

Each processor module has a 2k x 16 PROM and 4k x 16 to 16k x 16 RAM memory. Software required to load each processor RAM is located in PROM.

Ultraviolet eraseable PROM is implemented using the 2k x 8 2716 device, and RAM is implemented using the 4k x 1 2141 part.

Analog and discrete I/O conversions, and IEEE 488 data bus transactions are controlled directly by the 8086 processor.

The Bus Interface Unit (BIM) between the Intel 8086 Microcomputers and the IEEE 488 Data Bus is implemented using a TMS 9914 Talker/Listener interface chip and two 75160 bus drivers. The TMS 9914 is designed to perform the interface function between an IEEE 488 bus and a microprocessor. IEEE 488 standard protocol is handled automatically in Talker, Listener, or Controller operational modes.

3.4.1.2 Central Computer Input/Output — The central computer unit contains input/output (I/O) and control circuitry which is summarized as follows:

- 64 Discrete Input Channels
- 48 Discrete Output Channels
- 64 Analog A/D Input Channels
- 16 Analog Output Channels
- 1 Video Output to EHSI-CRT
- 12 (approx) Special input conversions (frequency to digital, frequency to voltage, miscellaneous discrete interfaces, etc.).
- 6 (aprox) -Gain of 100 buffered low level input conversions
- 4 Servo interfaces with associated logic.

6 AC input signal conversions including a demodulator controller, 1 Scott-T transformer, and 5 demodulators.
2 DABS serial digital interfaces (SM and ELM)
1 Hardware Real-time-clock counter
1 I/O control logic, including BIT logic circuitry.
1 Master clear detection and timing circuit and other special power handling circuitry.

3.4.1.3 Bubble Memory System — DAAS 1.024 mega-bit nonvolatile program storage is implemented using the Rockwell RLM 658 Bubble Memory Module, and the RCM 650 Bubble Memory Control Module. The memory system contains four 256k magnetic bubble devices using a block access design and organized as a 256k x 4-bit memory. All of the electronics necessary to operate the devices; i.e., sense amplifier, coil drivers, generator, and logic circuits are included. The four devices operate in parallel providing 4-bit-wide data which is routed to four of eight data interface lines, determined by a switch setting. The block length as seen at the output is 260 valid bits long. Four are designated as address bits and 256 as data bits.

3.4.1.4 EHSI Display Controller — The EHSI display is controlled by ALT-512 display controller located in the central computer unit. The ALT-512 is a complete graphics display controller on a single S-100 bus plug in board. It contains its own refresh memory, TV sync and video generator, and all I/O for the S-100 bus. Each display dot (pixel) is addressable via X-Y registers and can either be written into or read out. The board has six output and two input ports built-in. The display field consists of two 256 x 256 x 1 planes. Either or both planes can be displayed in various combinations.

3.4.1.5 Central Computer Power Supplies — The Central Computer Unit contains system power supplies. Power supplies convert 28 Vdc input power to 5 Vdc (Abbott BN100d-5A), and to 15 Vdc (Abbott BBN50D-15A). A 115 volt, 400 Hz power conversion is included for ±21 Vdc (unregulated) and 26 Vac power needs. A master clear generation circuit is also included in the central computer unit.

3.4.2 DAAS Radio System

The DAAS Radio System provides the communication and navigation radios for DAAS as well as the necessary data processing and information exchange between the DAAS computer and the system radios. The radio system is composed of the following units:

Radio Adapter Unit
KH 196 Comm 1 VHF

KY 196 Comm 2 VHF
KMA 24 Audio Panel (with KA 35A)
DME channeling switch and the ILS source switch
KN 53 Nav 1 VOR/LOC/GS
KN 53 Nav 2 VOR/LOC/GS
KN 62A DME

Following is a description of these radio system elements.

3.4.2.1 Radio Adapter Unit — The functions performed by the radio adapter unit (RAU) are:

- Tune the radios as commanded by the DAAS computer
- Process VOR/LOC/GS data from Nav 1 and Nav 2
- Process station identifiers
- Process DME distance
- Generate a radio system status word
- Format the data for block transfer
- Exchange information with the DAAS computer via the IEEE 488 bus

In addition to interfacing with the radio units, the RAU also interfaces with:

- 28-Vdc aircraft power
- KMA 24 audio panel (with KA 35A)
- KCI 310 FDI (through ILS source switch)
- KI 226 RMI (through the VOR source switch)
- DME channeling switch and ILS source switch
- DAAS/Manual status switch for each Nav receiver

The switches used by the pilot for radio system mode selection are:

Nav 1	Manual/DAAS
Nav 2	Manual/DAAS
DME	Nav 1/DAAS/Nav 2
ILS Source	Nav 1/DAAS/Nav 2
VOR Source	Nav 1/Nav 2

Complete pilot backup in a manual mode of operation is assured by the Manual position of the switches.

The DAAS system radio adapter unit (RAU) uses a microprocessor system for a flexible interface for control and data processing. The interface exchanges data with the DAAS Central Computer on the 488 bus using standard talker/listener functions and hand-shaking protocol. The processor receives tuning commands from the DAAS Central Computer. The processor then sends the tuning commands to the navigation and communication radios, processes the received navigation data and transfers this data in block format to the DAAS Central Computer. The data block transfers occur at a fixed rate of approximately 20 updates per second as required by the bus controller. A dedicated general purpose interface buffer (GPIB) handles the standard talker/listener protocol for transferring data. Data is stored in a buffer to eliminate slowing down the RAU processor. Bus setup time is $\leq 45\ \mu s$ and data transfer rate is $\leq 15\ \mu s$ per byte.

Nav 1 and Nav 2 provide a video composite with either VOR or LOC information modulated onto the 9960-Hz subcarrier. The interface circuit identifies what type of information is present, demodulates the composite, and digitizes the result. The VOR/LOC data from Nav 1 and Nav 2 can also be displayed on the KI 226 and the KCI 310 indicators. The specific display mode is a function of the status switches.

Glideslope information is also available from the KN 53 Navigation Receivers. The signal will be conditioned in the interface for digital conversion. The digitized data will then be processed and maintained in the data block for transfer to DAAS. As with VOR/LOC, glideslope information can also be displayed on the KCI 310 Indicator. The program will select the Nav unit to be displayed when in the DAAS mode.

To validate active channels of the navigation radios, the Morse Code identifiers will be read electronically, converted to the ASCII equivalent of the received Morse Code and transmitted to the central computer as part of the data block.

The RAU has capability to tune the KN 53 NAV Receivers, and the KY 196 COM Transceivers. The similarity in tuning procedure for the KN 53 and KY 196 allows a common method of tuning these radios. The interface will simulate the actions of the front panel rotary knobs by closing increment/decrement switches electronically to change frequency. The standby frequency only is affected by the tuning switches. To change the active channel, standby is tuned to the selected frequency, and an active standby exchange is executed. The approximate worst case tuning time for a KY 196 or KN 53 to sweep full band is 250 milliseconds. To execute an active/standby exchange, approximately 50 milliseconds is required. The hardware for tuning the KY 196 transceivers is included in the RAU, but not the necessary software.

The KN 62A DME can be tuned by command from the DAAS Central Computer, or by Nav 1 direct or Nav 2 direct through a common bus. The KN 62A tuning format is the 2 x 5 code. Approximately three seconds are required to tune the KN 62A and acquire valid range data.

To verify the auto tuning function, or to read the DME channel, data is read from the internal tune bus. This data is serial BCD information. A sync and clock are available to strobe this data into the interface.

Range information from the KN 62A is 18 bits of serial BCD data. A synchronous clock is provided to shift the data into the RAU interface for processing. The RAU microprocessor will convert this data to a 15-bit binary word (LSB = 0.02 NM) and maintain the current distance code in the data block for transmittal to the central computer.

3.4.2.2 Communication Radios — The DAAS communication radios consist of two VHF transceivers (KY 196 modified). These are located at the top of the radio stack as shown in Figure 1. They each have a standby and active frequency storage capability. Interchanging standby and active frequencies is accomplished by pressing a button on the front panel. They tune a frequency range from 118.0 MHz to 135.975 MHz. They have a minimum transmitter output of 16 watts and a receiver sensitivity of 2 μV for 6 dB s+n/n. They have automatic squelch with manual override on the front panel.

3.4.2.3 Navigation Radios — The navigation radios consist of two VOR/LOC/GS receivers (KN 53 modified) plus one DME receiver (KN 62A modified). These are located just below the communication radios. Active and standby frequencies are stored and displayed the same as in the communication transceivers discussed above. The VOR/LOC receivers tune the frequency range from 108.0 MHz to 117.95 MHz. As with the communication transceivers, these receivers can be locally or remotely tuned. The GS receiver is channeled from the LOC frequency selected. Forty channels of GS are available in the range of 329.15 MHz through 335.0 MHz.

3.4.2.4 DME — The DME receiver can be either remotely or locally tuned. In remote operation, it is channeled from the radio adapter box so that it can operate in conjunction with either of the VOR/LOC/GS receivers (Nav 1 or Nav 2). In the nonscanning mode the receiver can display distance to station. The DME tunes 200 channels, has a minimum output of 50 watts and a sensitivity of −82 dB minimum. The nominal search time is 3 seconds for range information.

3.4.2.5 Transponder KT 76A — The KT 76A is a radar beacon transponder that transmits on a frequency of 1090 MHz ± 3 MHz. Output power is 200 watts peak. The receiver frequency is 1030 MHz. An identify code number is selected at the front panel.

The KT 76A is capable of locating the user through the air traffic controller. Range and azimuth are established by the return from the transponder's pulsed transmitter, in reply to a routine interrogation from the ground radar site. When used in conjunction with an encoding altimeter, the KT 76A can be used to convey altitude information.

3.4.3 Flight Control Sensors, Servoactuators

The following flight control sensors, servoactuators are described below:

VG 208	Main System Vertical Gyro
KMT 112	Magnetic Azimuth Transmitter
KA 51A	Slaving Accessory
KSG 105	Directional Gyro
GG 2472	Yaw Rate Gyro
KDC 380	Air Data Computer (used for altitude error and IAS outputs only)
IDC 28702	Altimeter (corrected altitude)
Autopilot Servoactuators	

3.4.3.1 VG 208 Vertical Gyro — The Jet VG 208 Vertical Gyro is a remotely mounted electrically driven gyro which supplies attitude reference information to the KCI 310 Attitude Director Indicator. Additionally, pitch and roll attitude signals are supplied to the DAAS computer for use within the autopilot/flight director and navigation portions of the system. Required excitation input consists of 26 VRMS, 400 Hz. The output scale factors are 206 mV/deg commencing with zero (0) millivolts at zero (0) degrees.

3.4.3.2 KMT 112 Magnetic Azimuth Transmitter — The KMT 112 Magnetic Azimuth Transmitter, senses the earth's magnetic field and furnishes this information to the KSG 105 Slaved Directional Gyro as an 800-Hz synchro control transmitter type output. Input power of 4.75 VRMS, 400 Hz, is required and is furnished from the KSG 105.

3.4.3.3 KA 51A Slaving Accessory — The KA 51A is a slaving accessory used in conjunction with the KSG 105 Directional Gyro and KMT 112 Magnetic Azimuth Transmitter to comprise the KCS 305 Slaved Gyrocompass System. The KA 51A is a panel mounted unit that displays the slaving error between the KSG 105 and the KMT 112. Required power inputs consists of +12 Vdc and 13 VRMS, 400 Hz (both voltages from the KSG 105). The slaving meter drive signal is furnished by the KSG 105. Manual slave signals are pilot initiated through the activation of the push button switches which are part of the KA 51A.

3.4.3.4 KSG 105 Slaved Directional Gyro — The KSG 105 Slaved Directional Gyro provides gyro-stabilized aircraft heading information to DAAS. It requires 115-Vac, 400-Hz sinewave, input power. Additionally, it requires a signal input from the KMT 112 Magnetic Azimuth Transmitter and a synchro excitation voltage of 26 Vac, 400 Hz.

3.4.3.5 GG 2472 Yaw Rate Gyro — The GG 2472 Rate Gyro is used to detect yaw rate and input this information to the DAAS computer. The unit is a spring restrained, fluid damped, gyroscope with a synchronous hysteresis spinmotor and a variable reluctance signal generator. The self-contained demodulator outputs the dc rate signal for use by the computer.

Input requirements consist of single phase, 26-VRMS, 400-Hz excitation and input power (26 V; 7 VA). Sync time is typically less than 60 seconds, and the rate scale factor (volts dc/deg/sec) is 0.200 ±10%. Threshold is less than 0.01 deg/sec and the rated output load is 10 k.

3.4.3.6 KDC 380 Air Data Computer — The KDC 380 Air Data Computer is an electromechanical unit that senses pressure inputs (total and static), and provides signals of altitude for altitude hold and indicated airspeed for configuration monitoring.

3.4.3.7 IDC 28702 Altimeter — The encoding altimeter provides a pressure altitude signal to the KT 76A Transponder and also a corrected altitude signal to the DAAS computer. The corrected altitude signal is the primary DAAS VNAV altitude reference. When pressure altitude is required it is computed from this signal and the pilot entered altimeter setting.

3.4.3.8 Autopilot Servoactuators — The DAAS Autopilot servoactuator mechanization is illustrated in Figure 5. Shown are the pitch servoactuator, roll and yaw servoactuator and the pitch trim servoactuator mechanization. The electric servos are clutch activated for autopilot engagement. All servos except the trim servo include tachometer rate sensing for servo loop stabilization.

The pitch servoactuator includes torque switches for auto trim engagement. Clockwise and counterclockwise torque limit sensors are located on the engage plate. As the motor turns in either diection, the load causes the motor assembly to move laterally, actuating the small microswitches on the engage plate. Screws on the front of the engage plate enable the switches to be positioned to detect factory specified torques. The normally open contacts of each switch are routed to the DAAS computer as an indication that auto trim signals should be activated.

The pitch trim servo includes a transfer relay to switch from manual to automatic trim.

3.4.4 Engine Sensors

The following engine sensors are used to supply inputs to the DAAS computer:

RPM Sensor	(2)
Manifold Pressure	(2)
Fuel Flow Sensor	(2)

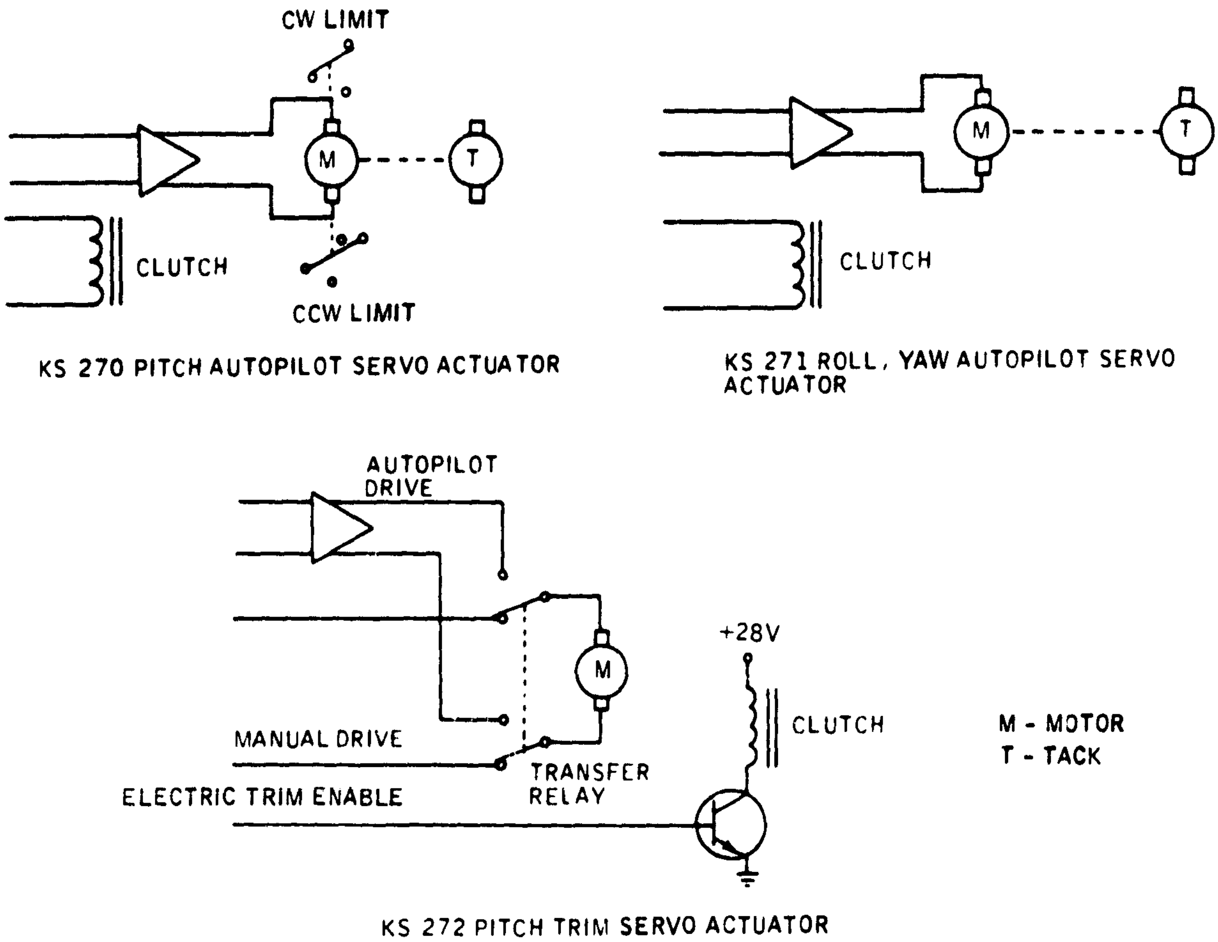


Figure 5. DAAS Autopilot Servo Actuator Mechanization

3.4.4.1 RPM Sensor — Tach generators mounted on each engine provide RPM data to the DAAS computer. The Tachometer outputs a varying frequency signal with 1 Hz corresponding to 60 rpm. The variable frequency signal is converted to dc in a NASA signal conversion box, resulting in a 1.67 mv/rpm signal scale factor.

3.4.4.2 MAP Sensor — The MAP sensor is a small, high accuracy semiconductor strain/gage, a Celesco PLC-20-A2 device. The temperature compensated sensor provides a pressure signal with 20 psi range.

3.4.4.3 Fuel Flow Sensor — The DAAS Fuel Flow Sensor is the Flo Scan 200 Turbine Flow Transducer.

Series 200 turbine flow transducers measure flows of hydrocarbon fuels such as gasoline, kerosene, and No. 2 diesel fuel and other light transmitting, non-corrosive liquids of similar viscosity.

The transducers give linear signals on gasoline across a 100-to-1 flow range down to 0.3 GPH. The transducers produce a current pulse signal from an opto-electronic pickup.

Liquid enters the flow chamber tangentially, follows a helical flow path, and exits vertically, thereby venting any entrained vapor bubbles. The rotational velocity of the liquid is directly proportional to flow rate. A neutrally buoyant rotor spins with the liquid between V-jewel bearings. Rotor movement is sensed when notches in the rotor interrupt an infrared light beam between an LED and photo-transistor.

3.4.5 Configuration Status Sensors

The following conditions are sensed and input to the DAAS computer to be used for status correlation and displaying warnings to the pilot as necessary.

Wing Flaps - Position transmitter indicating flap positions of 0°, 15°, 30°, and 45° will be monitored.

Cowl Flaps - Cowl flap position is determined using a pot transducer.

Aux. Fuel Pumps - The 3-position auxiliary fuel pump switches are monitored to determine when the switches are in the "on" position.

Cabin Doors - Switches are included to sense whether or not the doors are latched and secure.

Trim - Elevator trimpot is monitored to ensure that the trim is within take off limits.

Landing Gear - Existing limit switches and gear-on-ground switch are monitored to give indications of gear down and locked, squat and gear up.

Radar Altitude - Radar altitude is provided by an RT-221 Radar Altimeter. The ground proximity warning function uses radar altitude in conjunction with barometric altitude rate.

3.4.6 Miscellaneous Sensors

DAAS sensors also include True Airspeed (TAS) and Outside Air Temperature (OAT):

3.4.6.1 TAS Sensor — The DAAS TAS sensor is the J-TEC VA 210 Vortex Airspeed Sensor. The sensor provides a digital output signal at 45 Hz/kt to 200 kt airspeed.

3.4.6.2 OAT Sensor — The DAAS OAT sensor is a Rosemount 101F sensor. The temperature sensing element is a fast response, open wire, platinum resistance type element having 50 ohm resistance at 0° C.

3.4.7 DABS

A demonstration test bed for the Discrete Address Beacon System (DABS) is included in the DAAS system. This function, as described in paragraph 5.9, is mechanized in CC CPU-6 and interfaces with the DABS transponder and IDCC display.

3.5 DAAS POWER DISTRIBUTION

Cessna 402B power distribution is illustrated in Figure 6, and power controls are shown in Figure 7.

DAAS power comes from the aircraft alternator (battery) bus and is backed up by a dedicated DAAS battery, resulting in uninterrupted dc power.

When the avionics bus is off, the DAAS battery is disconnected from the aircraft alternator bus so power cart transients are avoided. When the avionics bus is turned on, the DAAS battery is connected to the aircraft alternator bus, and if the DAAS battery is low, it is charged rapidly. The DAAS system is diode coupled to the alternator bus, so it is not used for starting and low-voltage transients will not propagate to the DAAS. The DAAS battery can be disconnected from the alternator bus at any time by opening the DAAS battery charging circuit breaker.

Aircraft power controls are located on the overhead control panel, and the DAAS power switch (locking switch) is located above the left circuit breaker panel, Figure 7.

The control pedestal circuit breaker panel provides circuit breakers to protect circuits associated with the DAAS components. A guarded preflight/normal switch is also located on the circuit breaker panel. The purpose of this switch is to allow the use of DAAS for preflight flight planning with minimum battery drain (engines off). The DAAS battery supplies power for this function with the aircraft battery switch off.

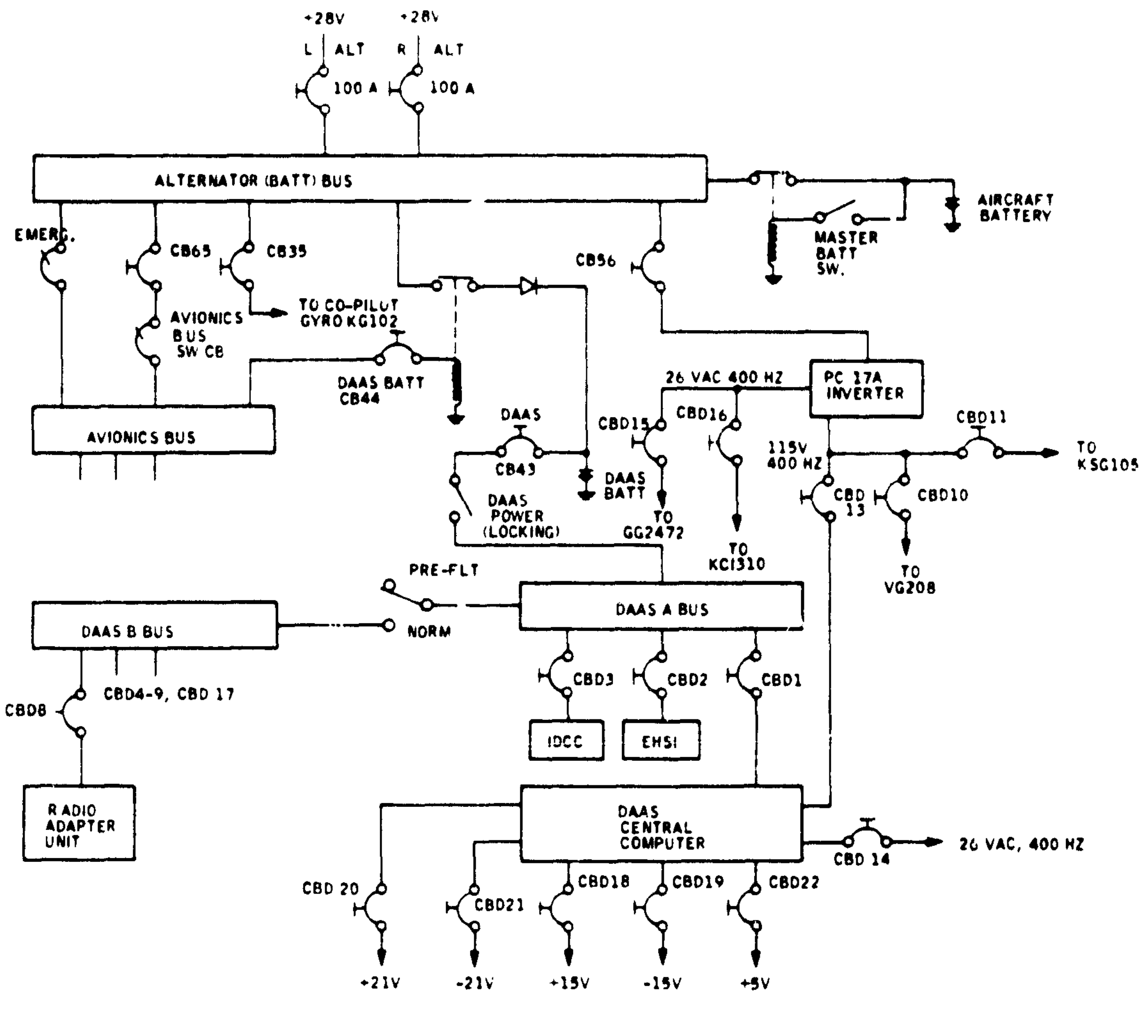


Figure 6. Cessna 402B Simplified Power Distribution

With the DAAS power switch ON and the preflight/normal switch in the PREFLIGHT position, power is supplied only to the DAAS Computer, IDCC, and EHSI. In the NORMAL position, power is also supplied to the servo actuators, mode select panel, annunciator panel, attitude director indicator, and several sensors.

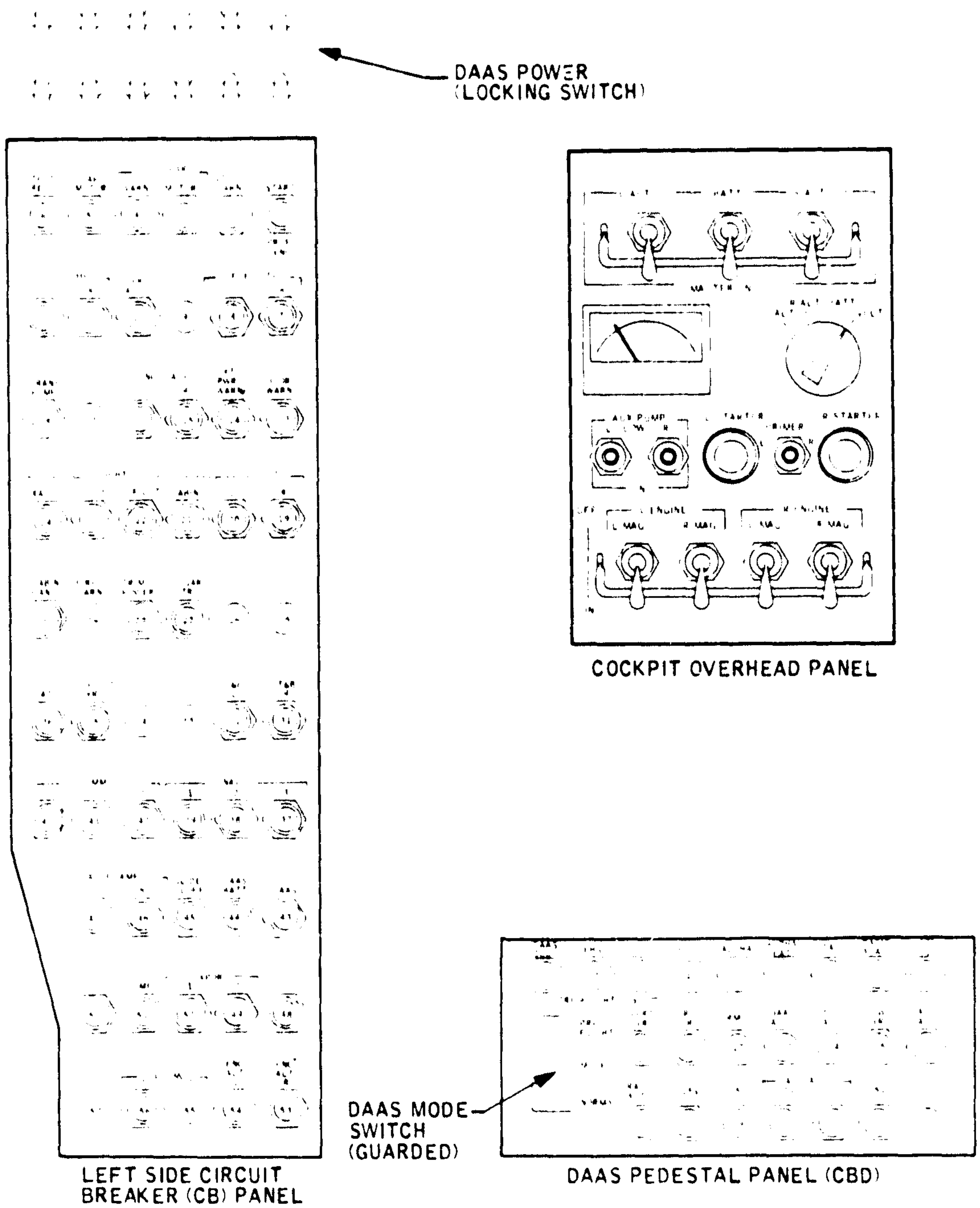


Figure 7. DAAS Power Controls

Section 4.0
DAAS Multifunction Controls and Displays: IDCC and EHSI

The DAAS system employs multifunction controls and displays including an Integrated Data Control Center (IDCC) and Electronic Horizontal Situation Indicator (EHSI). These multifunction controls and displays are involved in many of the DAAS functions and are thus introduced here preliminary to discussion of the individual functions in Section 5.0.

4.1 INTEGRATED DATA CONTROL CENTER (IDCC) DESCRIPTION

The DAAS IDCC is shown in Figure 8. Two rows of push buttons located across the top of the device are 1) NAV function controls, and 2) display page select buttons. Data entry keyboard and special controls are located below the IDCC display.

Following is a description of the IDCC controls and display. NAV function controls located above the IDCC display are described in Section 5.0.

4.1.1 Page Select Buttons

Page select buttons above the IDCC display are used to call up various function display pages.

4.1.2 IDCC Display

The 4.5 by 4.5-inch IDCC display is capable of displaying 16 lines of 32 characters. Available characters are presented in Figure 9. Line spacing is 0.25 inch, and character height is 0.162 inch. Character width is 0.125 inch. The center of the first line of characters is 0.45 inch from the top of the screen. The display general layout is shown in Figure 10.

The display top line is reserved for the label or title of the page and the page number. The second line can be used for any desired text. The lower left hand corner, 10 characters wide is reserved for data entry scratchpad. The remainder of the lower two lines are reserved for warning messages.

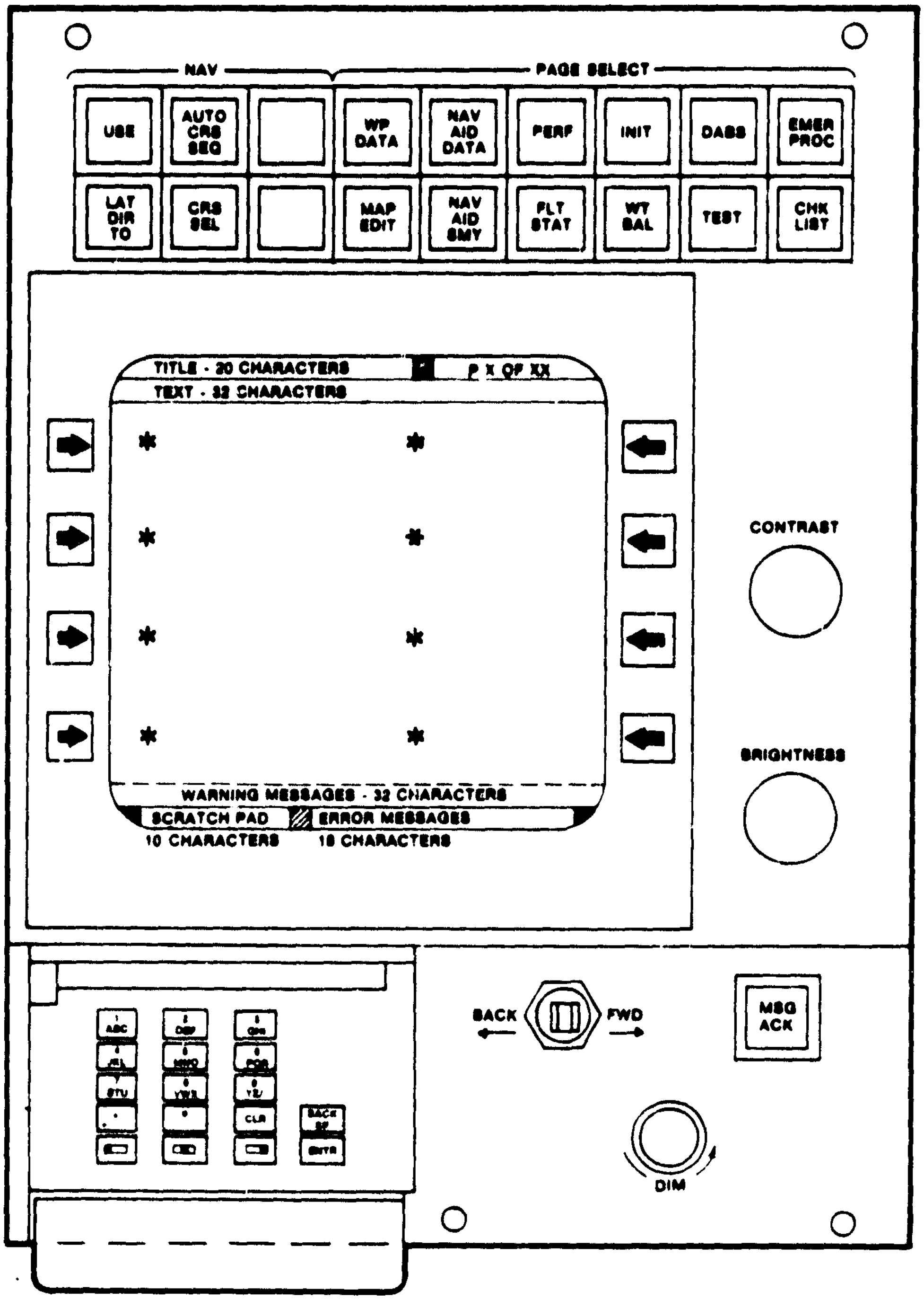


Figure 8. Integrated Data Control Center

α	β	γ	δ	ε	ζ	η	θ	ι	κ	λ	μ	ν	ξ	ο	π
ρ	σ	τ	υ	φ	χ	ψ	ω	Ω	√	→	←	↑	÷	Σ	≈
	!	"	#	$	%	&	'	(	)	*	+	,	—	.	/
Ø	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	⌒	_
'	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
p	q	r	s	t	u	v	w	x	y	z	{	¦	}	~	■

Figure 9. IDCC Character Set Definition

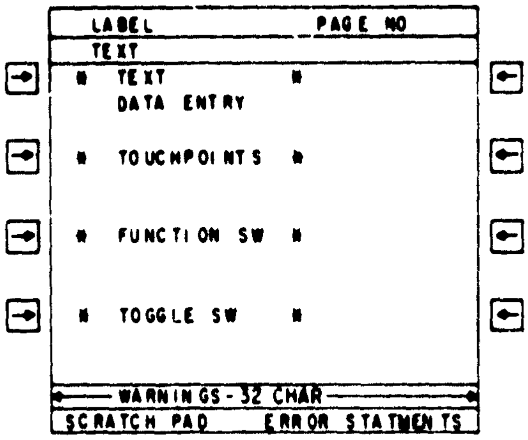
Standard page formats have been defined for the IDCC display. These are shown in Figure 10. A mixture of these formats is possible.

4.1.3 IDCC Touch Panel, Bezel Buttons

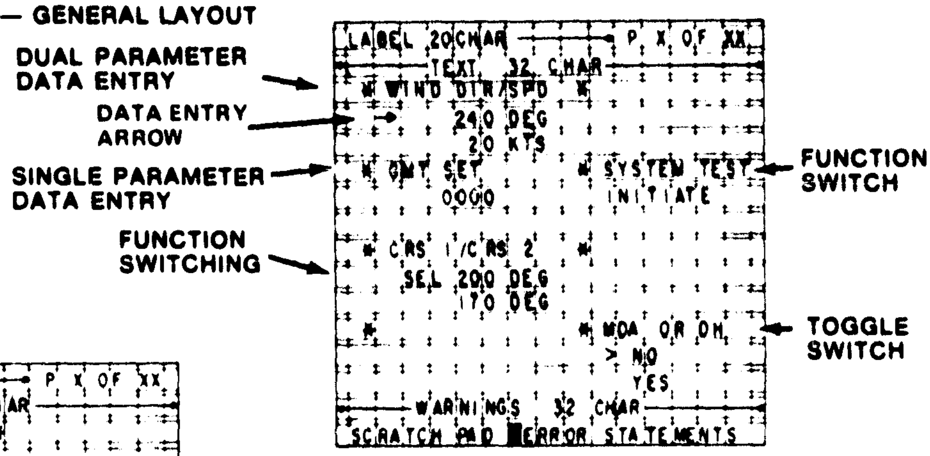
The IDCC has a touch panel superimposed on the face of the display. It is implemented with a pressure sensitive CRT overlay. The touch positions are set up in a 2 (horizontal) by 4 (vertical) matrix. This allows the pilot to select one of 8 points on the IDCC display. Touch points are located at the asterisk symbols on the IDCC touchpoint display format of Figure 10. The pressure sensitive overlay can be replaced by a set of bezel mounted buttons which are used as an alternate to the touchpoint selection.

The touchpoints (or alternate bezel buttons) are used in data entry, function switching, and toggle switching. Data entry is described in paragraph 4.1.6.

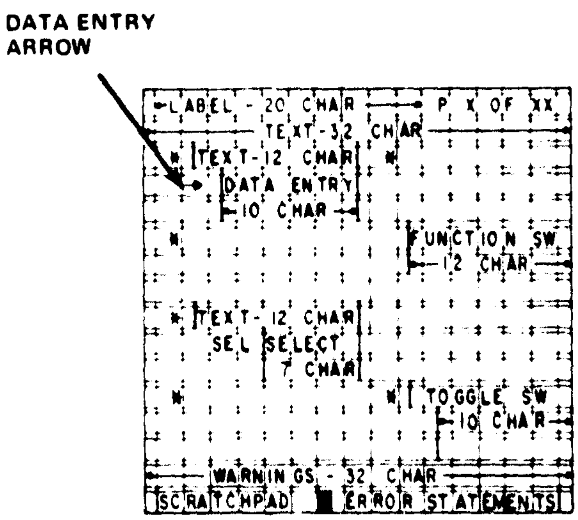
For function switching, touchpoint (or bezel button) activates a function, e.g., selects a page or selects a function. Touching a toggle switch touchpoint will toggle to the other function. For example, a toggle switch can be used to toggle between MDA or DH active or not active modes. See Figure 10 for examples.



IDCC TOUCHPOINT DISPLAY — GENERAL LAYOUT

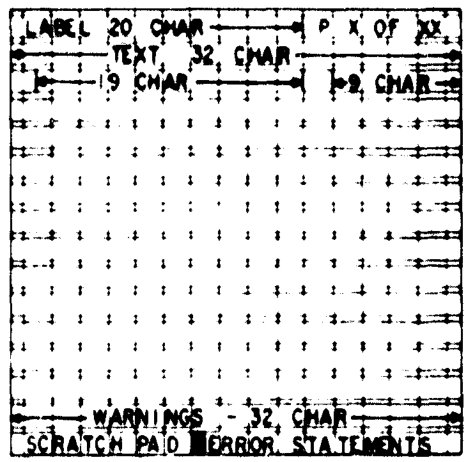


IDCC TOUCHPOINT SWITCHING — EXAMPLES

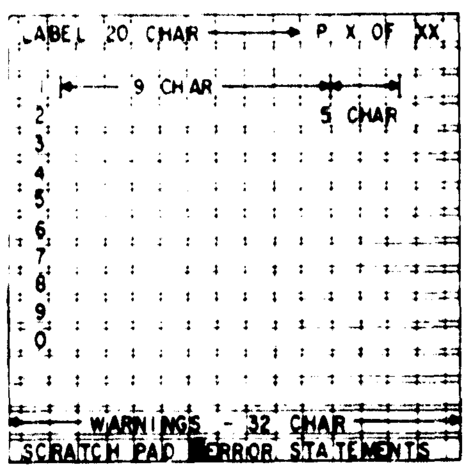


IDCC TOUCHPOINT DISPLAY — STANDARD FORMATS

Figure 10. IDCC Display Page Formats



CHECKLIST FORMAT



TABULATED DATA FORMAT

Figure 10. IDCC Display Formats (Concluded)

4.1.4 IDCC Keyboard

The IDCC keyboard, Figure 11, allows both alpha and numeric character entry. Each key has one numeral and three alpha characters. Alpha character entry requires two button pushes. First one must press the key with the triad of alpha characters that includes the desired alpha character, and then press one of the three post designation keys to select the 1st, 2nd, or 3rd alpha character of the triad. The software assumes a numeric entry unless a post designator is pressed. Thus, no post designator is required for numeric entry. The three keys along the bottom are the post designators

Back space, enter, and clear keys operate as follows:

BACKSPACE — Used to backspace in scratchpad (SPAD) data entry operation for error correction.

ENTER — Transfers data from scratchpad to entered data.

CLEAR — The action taken when the CLEAR entry key is depressed depends on the state of the IDCC display when depressed.

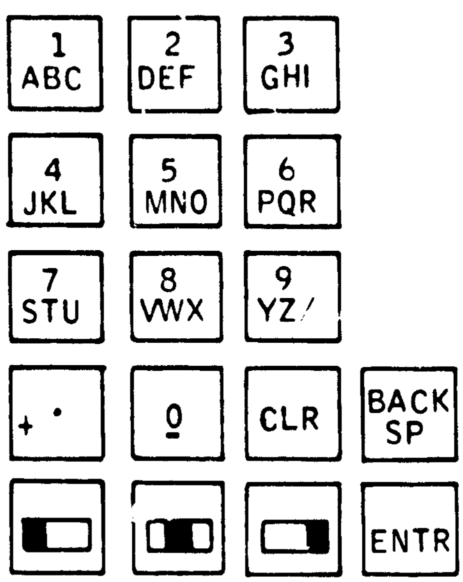


Figure 11. Keyboard Layout

4.1.5 IDCC Miscellaneous Controls

The three controls below the IDCC display have these functions:

BACK-FWD — Changes page selection to the previous page or the next page in a sequence. If the last in a sequence is encountered, a next page selection will call up the first page in the sequence.

MSG ACK — Used to acknowledge warning messages, remove the message, and extinguish the warning light.

DIM — The DIM control varies the light intensity of the keyboard, the AUTO CRS SEQ pushbutton, and EHSI control buttons.

4.1.6 IDCC Data Entry

For pilot convenience, data entry on a page sequences automatically down the left side of the page and then down the right side. When the pilot touches a data entry touchpoint, a data entry arrow appears on the screen at the item to be entered. After the pilot enters that item, the arrow moves to the next data entry location. When all related data on the page is entered the arrow disappears.

Data can be entered one parameter per touchpoint (single parameter data entry) or two parameters per touchpoint (dual parameter data entry). See Figure 10 for examples.

4.1.6.1 Single Parameter Data Entry — Pressing a touchpoint will cause the arrow to point to entry (see standard format, Figure 10). Data is entered into scratchpad via keyboard. Push ENTER key. If data is valid, it will be entered.

If data is found to be not valid, the arrow stays and an error message is displayed. Entry of blanks will leave data in the variable space unchanged. Touching the same touchpoint again will cause the arrow to disappear.

If no entry is desired, depressing the keyboard clear button (CLR) with the scratchpad cleared will cause the entry to change to its power-up value.

When no entry arrow exists, no data entry error or system operation error message is displayed and the SPAD is clear, the CLEAR entry is ignored.

When a value exists in the SPAD, but no warning or error message exists, selection of the CLEAR entry will clear the SPAD, but leave the data entry arrow unaffected.

When a data entry error message exists along with the erroneous entry in SPAD, selection of the CLEAR entry will clear the spad and the error message, leave the entry arrow unaffected, and enable further entries.

When a system operation error message exists, selection of the clear entry key will clear the error message and enable further entries into the system.

4.1.6.2 Dual Parameter Data Entry — The touchpoint bezel button will produce an arrow (Figure 10) which will point to first entry. If the arrow shows on one of the two lines, it will toggle with subsequent touches.

Data is entered the same as for single parameter entry. On entry of the first parameter, the arrow will move to the second line. On entry of the second line, the arrow will go away and entry is considered complete. Blanks will be a valid entry and will imply that data in the variable space are not to be changed. "No entry" can be effected in the same way as stated above for single parameter data entry.

When a valid entry is made at a touchpoint, the entry will be transferred to its indicated position on the display.

The entry arrow automatically proceeds to the next data entry touchpoint when an entry is made. Entering data in the last data entry touchpoint clears the arrow. Touching any data touchpoint moves the entry arrow to that location. If other than a data entry touchpoint is touched, the arrow is cleared.

4.1.6.3 Data Entry General Requirements — All data must be entered right justified. Digits will move from right to left as additional entries are made. A decimal point is assumed after the last character entered if no decimal point has been entered.

When you leave a set of pages and return, you will always go back to page 1 with the exception of the WP DATA page.

When a WP DATA page is selected by IDCC push button, the waypoint data page corresponding to the active waypoint will appear.

The scratchpad is cleared automatically each time the data entry arrow is moved.

Power-up values shall in general be zeros or nominal values. Xs are used if a specific objection to the use of zeros or nominal values is apparent.

4.1.6.4 Data Entry Errors and System Operation Diagnostics and Advisories — A data entry error is defined as an illegal entry made via the IDCC keyboard/enter key. A system operation error is defined as an action that commands the system to assume an abnormal state.

Either type of error, if detected, generally will result in the DAAS rejecting the command that caused the error. A message will appear in the error statement portion of the IDCC upon pushing the ENTR key or improperly using a touchpoint. The error statement is cleared by depressing the CLR key which also clears the scratchpad and allows subsequent touchpoint or bezel button operations.

A data entry error is caused by keyboard entry of illegal characters, illegal format, invalid frequency, etc. An error message is displayed and the keyed-in value remains in the scratchpad. No system entry occurs.

A system operation error is the result of a touchpoint or push button selection when incomplete data exists or the system state is incompatible with that selection. For example, an attempt to use a waypoint that is in no way defined will result in no system action and an operation error diagnostic. In some cases, the entered data is accepted, and only an advisory message is displayed.

Entered data format errors result in an IDCC message "DATA ENTRY ERROR," and disabling of IDCC controls until the message is cleared. The following format errors are detected:

1) Too many characters to left of decimal point
2) Illegal characters; i.e., inappropriate alpha or numeric characters
3) Out of range entries; i.e., an entry which exceeds the parameters scaling limits.

Data entry errors and operator errors are tabulated in Table 1.

Table 1. IDCC Data Entry Operation Error Messages

Function, IDCC Page	Error	Message
ALL	Entered data outside acceptable range, illegal format	DATA ENTRY ERROR
NAVID DATA Page	Invalid frequency entry Magnetic variation faulty prefix	DATA ENTRY ERROR
	Change in referenced data	*NAV USED IN WP DEF
WP DATA Page	Invalid frequency entry	DATA ENTRY ERROR
	NAVAID number entered with no stored NAVAID data	NO NAVAID DATA
	RNAV mode select with LOC frequency	LOC FREQ SELECTED
MAP EDIT Page	Start waypoint relative position not discernible	WP NOT LOCATED
	End waypoint number less than start waypoint	WP LESS THAN START
	End waypoint position not discernible	WP NOT LOCATED
	Inserted waypoint exceeds 10	WP STORAGE LIMIT
	Active waypoint detected	ACTIVE WP
	Present position waypoint NAVAID not received	INVALID RADIO
USE Button	USE attempted with incomplete waypoint data	WP NOT DEFINED
CRS SEL	Selected course not defined	COURSE NOT DEFINED
AUTO CRS SEQ	Course 2 not defined	CRS 2 NOT DEFINED
LAT DIR TO	Active waypoint not RNAV	NOT RNAV WP
	Active waypoint incomplete	WP NOT DEFINED
DABS "SEND"	Incomplete Weather Request Data	DATA INCOMPLETE

*Advisory message only. Data accepted into system.

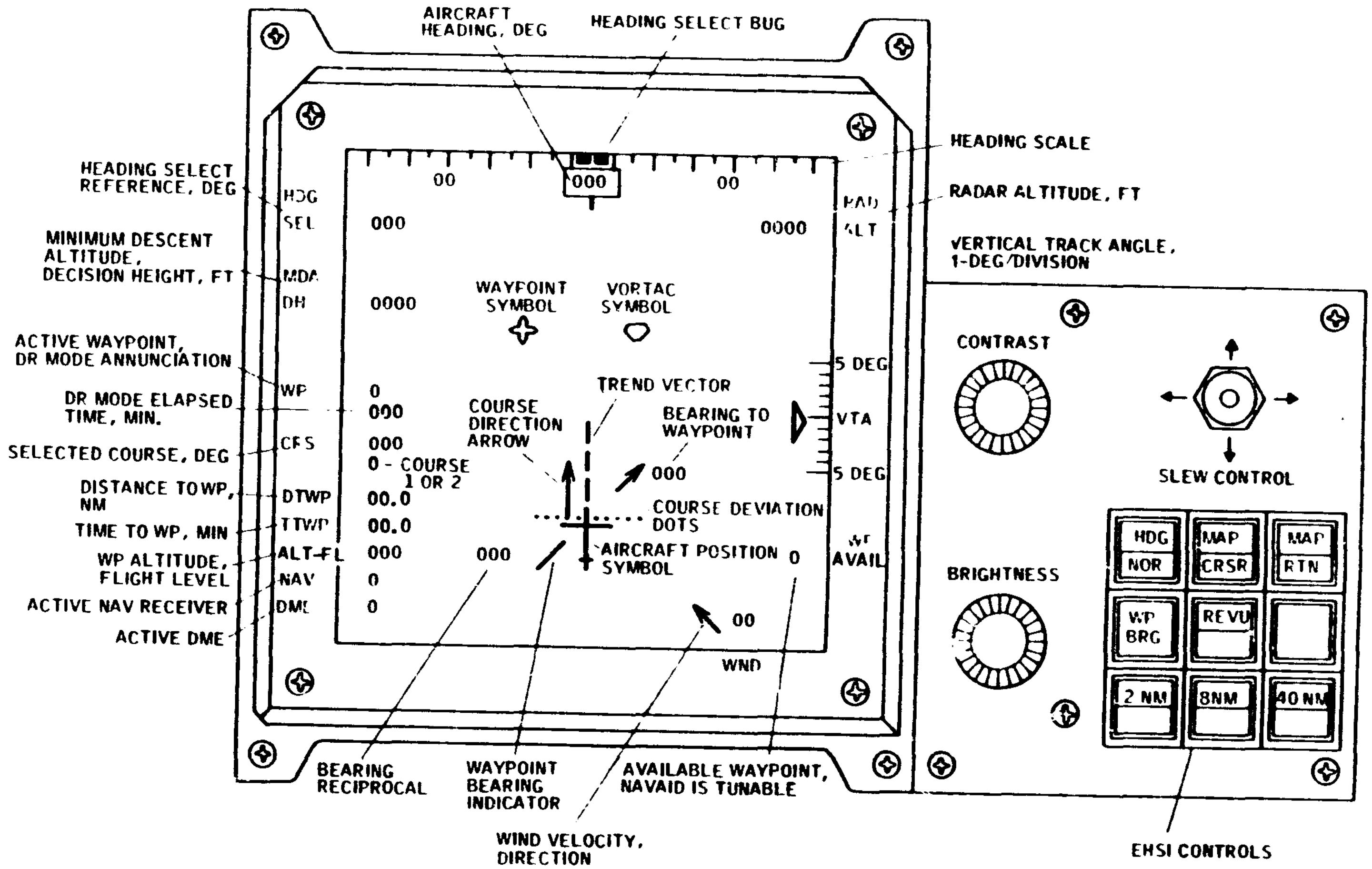


Figure 12. DAAS EHSI

4.2 EHSI DESCRIPTION

The DAAS EHSI is presented in Figure 12. EHSI controls are located to the right of the EHSI display.

4.2.1 EHSI Display

The general EHSI display format is shown in Figure 12. Following is a description of the displayed symbology.

Heading scale located across the top of the display is 0.375 inch for each 10-degree marker. The marker extends down 0.125 inch on the display. Short markers are located between the 10-degree marks and are 0.0625-inch down from the top of the display. The letters N, S, E, and W are used for North, South, East, and West headings.

A rectangle, 0.60 by 0.28 inch, is located in the center of the display 0.125 inch from the top. This rectangle contains three numbers for the current magnetic heading of the aircraft. The numbers are 0.17-inch high and 0.15-inch wide. If any digit of a number on the heading scale starts to enter the area of this rectangle, that number on the heading scale will disappear.

The selected heading is indicated by both a heading bug and a digital readout. Heading select numbers are displayed on the left side of the display 0.75 inch from the top. HDG SEL is written on the bezel. The heading bug is as shown in Figure 12. When a heading is selected that is off the scale one half of the heading bug will position itself on the side of the heading scale where the bug will appear as the aircraft turns to the selected heading.

The aircraft symbol is in the center of the display with the wing and fuselage intersection located 1.3 inch up from the display bottom. The wing has a span of 0.5 inch and attaches 0.125 inch aft of the nose of the fuselage. The fuselage is 0.5 inch long. The horizontal stabilizer is 0.0625 inch forward of the aft end of the fuselage and has a span of 0.125 inch. The row of 10 dots 0.125 inch apart passes through the fuselage 0.0625 inch aft of the forward end of the fuselage. The fuselage is made up of three parallel lines that are separated by 0.020 inch, the pixel spacing. The wing is made up of two lines. The purpose in both cases is to create contrast between the airplane and other course lines.

An active waypoint bearing needle pivots about a point 0.0625 inch aft of the fuselage nose. The needle or arrow shaft with the arrow head starts 0.35 inch from the pivot point and is 0.35 inch long. The tail of the arrow starts 0.35 inch from the pivot and is 0.35 long.

Next to the head of the arrow are the bearing numbers and next to the tail are the reciprocal bearing numbers. The bearing numbers are shown to the right of the arrowhead if the arrow points to the right and vice versa. The reciprocal bearing numbers are shown on the side opposite the bearing numbers. A button marked waypoint bearing (WP BRG), located below the slew control, if pushed, will delete the waypoint bearing needle display or, if pushed a second time, will return the display. The purpose of the bearing needle is to help the pilot, if he becomes confused, to determine his position. The waypoint needle always points to the active waypoint.

Turn trend lines are provided on the 2-nm/inch and 8-nm/inch RNAV displays. These are comprised of three line segments. The end of the first segment is where the aircraft will be in 30 seconds. The second segment is a straight line between the points where the aircraft will be in 35 seconds and where the aircraft will be in 60 seconds. Similarly, the third line segment joins the points representing the aircraft's projected location at 65 and 90 seconds in the future. When the aircraft exceeds 30 degrees of bank angle, the trend lines disappear.

A Course Direction Arrow (CDA) line is provided to assist the pilot in getting on his selected course in an expeditious manner if he should become disoriented and positioned off the course line. The CDA is a line 0.50 inch long which originates at and is at 90° to a line through the ten course deviation dots. The CDA is in the direction of the selected course and has an arrowhead on the end. The CDA is coincident with the selected course line. When the CDA reaches waypoint it continues through the waypoint outbound on the same course as the inbound. If auto sequencing of waypoints has been selected, the CDA will snap to the new course automatically when the position is reached where a turn to capture the outbound course should be initiated. If auto sequence has not been selected, the CDA will continue to point in the inbound course direction until the outbound course is manually selected.

The symbol for a waypoint is a four-corner star similar to the one used in Jeppesen publications. The symbol for a VORTAC station is a triangle with the corners cut off, with one base side at the top and horizontal.

The dimensions of the waypoint symbol are such that it can be inscribed within a 0.25-inch-diameter circle. The NAVAID symbol is sized so it may be inscribed in a 0.187-inch-diameter circle. Waypoint numbers (0.17-inch high) are shown below and to the right of the waypoint symbols. ID letters (0.17-inch high) for NAVAIDs are to the

right of the NAVAID symbol. These letters and numbers need to be close to the related symbol, but far enough away so that both are legible when a waypoint and NAVAID are co-located.

The MDA (Minimum Descent Altitude) and DH (Decision Height) legends are shown on the left side of the display on the bezel below the HDG SEL centered 1.25 inches and 1.5 inches respectively below the top of the display. The MDA or DH altitude is shown in feet MSL on the display 1.5 inches from the top of the display and 0.125 inch from the left edge. Both MDA and DH warnings are based on barometric altitude.

On the left side of the display on the bezel, is the WP (Waypoint) which is written 2.1 inches from the bottom of the display. CRS (course) on the bezel is located 2.6 inches from the top. DTWP (distance to waypoint) is located 3.1 inches from the top, TTWP (time to waypoint) is located 3.35 inches from the top, ALT (selected or waypoint altitude) is located 3.6 inches from the top, NAV is written 3.85 inches from the top, and DME is written 4.1 inches from the top. The numbers appropriate for the bezel letters are located 0.125 inch in from the edge of the display. If the navigation system is in the dead reckoning mode (due to a loss of radio signal), the letters DR (dead reckoning) appear next to the waypoint number and blink once every second. If the navigation system is in VOR or ILS, these letters will appear next to the waypoint. No letters next to the waypoint number indicates the system in the RNAV mode. When the navigation system is in the DR mode, the number of elapsed minutes the system has been in the DR mode will be displayed directly below the waypoint number.

Next to CRS is the three number selected course on the display. Directly below the course numbers is a number which designates whether course 1 or 2 is displayed. Next to DTWP is noted the nautical miles from the aircraft to the waypoint. Next to TTWP is noted the minutes the aircraft will take to reach the WP at the present ground speed. Next to ALT, the selected altitude in hundreds of feet is displayed. Next to NAV on the display appears the number of the navigation receiver being used for the active WP. The number will blink once per second if the radio signal being received is indicated as being invalid. If both receivers are invalid, and both are in the DAAS tuning position, blinking "1" and "2" will be alternately displayed at 2-second intervals. The number opposite the DME marking will show the number 1 if a valid DME signal is being received, will blink if the signal is indicated as invalid and be blank if VOR/ILS has been selected, or if manual DME tuning is selected.

The wind information is displayed 0.65-inch in from the lower right corner of the display. WND is written on the bezel on the bottom edge of the display. The velocity in knots is displayed 0.25 inch from the bottom of the display above WND. The pivot point is located 1.10 inch from the right edge of the display and 0.30 inch above the bottom of the display. The arrow points in the magnetic direction of the wind relative to the displayed map. The arrow is 0.40 inch long with a pivot in the center.

Waypoint available is written (WP AVAIL) in the bezel. The waypoint number is displayed 0.75 inch from the bottom of the display. When the number appears the strength of the associated radio signal is such that the waypoint can be used for navigation.

The vertical track angle (VTA) is located on the right side of the display 2.125 inches from the bottom. VTA is written on the bezel. Each division on the VTA scale is equal to one degree of track angle and on the display the indicator marks are 0.10 inch apart. There is a small triangle shaped indicator on the display that shows the track angle to fly a course in a vertical plane to reach the altitude of the next waypoint at that waypoint.

The aircraft radar altitude (RAD ALT) is displayed on the upper right side of the display 0.75 inch from the top. When the aircraft is more than 2500 feet above the ground, no numbers are shown.

4.2.2 EHSI Controls

Figure 12 also shows the EHSI controls. The switches perform functions as follows:

HDG/NOR — HDG/NOR changes the map from heading-up to a North-up orientation and vice versa. Lighted annunciation.

MAP/CRSR — MAP/CRSR changes the slew control to effect the cursor or the map. In the cursor selected state a cursor appears superimposed on the active waypoint. Lighted annunciation.

MAP RTN — MAP RTN returns the map to its normal position (not slewed/map mode).

MAP REVU — MAP REVU causes the map to appear when no radio signals are available. The active waypoint is located at the airplane location. The purpose of MAP REVU is to allow preflight review of the planned flight using the map slew feature. The aircraft symbol is not displayed during MAP REVU. Lighted annunciation.

2 NM/IN — Map scale select. Lighted annunciation.

8 NM/IN — Map scale select. Lighted annunciation.

40 NM/IN — Map scale select. Lighted annunciation.

SLEW CONTROL — The slew control is used to position a cursor on the EHSI map or to move the map itself. If a cursor is positioned, the purpose is to designate a location on the map for a waypoint. If the map is slewed, the purpose is to view portions of the map which are otherwise out of view because of EHSI scaling and size limitations. The normal mode will be the map slew mode.

The slew control is implemented using a nine-position switch. Selection of the Map or Cursor Slew modes is made by depressing the appropriate push button switch. Pressing the cursor control lever all the way in any of the four directions as shown will cause a fast slew of the map or cursor in a corresponding direction. Pressing the lever half way results in a low speed slew in that direction.

The switch is spring loaded to the center off position. When it is released in the cursor slew mode, the cursor will remain fixed to the map and will translate along with the other map attributes.

Upon switch release in the map mode,the map will remain at a fixed displacement from the aircraft's present position in accordance with the past use of the slew control. The map may be returned to its original airplane oriented position by activating the "MAP RETURN" switch. The fast slew rate has been selected as 1-inch per second. The slow slew rate is 0.2-inch per second.

Section 5.0
DAAS Function Description

DAAS Functions include:

- Autopilot
  - Yaw Damper
  - HDG SEL (Heading Select)
  - ALT, ALT ARM (Altitude Hold, Altitude Arm)
  - NAV, VNAV Coupled Control
  - Approach Coupled Control
- Navigation/Flight Planning
  - VOR, VOR/DME Radio Navigation
  - 10 Waypoints, 10 NAVAID Storage
  - Kalman Filter Blending
  - Moving Map Display
- VNAV (Vertical Navigation)
- Flight Warning/Advisory System
  - Engine Parameter Monitoring, Warning
  - Aircraft Configuration Monitoring, Warning
  - Ground Proximity Monitoring, Warning
  - Airspeed and Stall Monitoring, Warning
  - Altitude Advisory Function
  - Marker Beacon Advisory Function
  - NAVAID Identification Monitoring, Warning
  - Autopilot/Flight Director Monitoring, Warning
  - BIT Fault Warning
- GMT Clock Function
- Fuel Totalizer Function
- Weight and Balance Computations
- Performance Computations
  - Takeoff Performance
  - Cruise Performance
  - Fuel/Distance Time Computations
- DABS (Discrete Address Beacon System) ATC Communications, Weather Reporting
- BIT (Built in Test)
- Normal, Emergency Checklists

Follwoing is a description of these DAAS functions.

5.1 DAAS AUTO PILOT/FLIGHT DIRECTOR FUNCTION

The Autopilot/Flight Director Function computes commands to the yaw, pitch, and roll servos to provide stability augmentation and autopilot functions. It also provides signals to the flight director indicator. The status of the system is reported by lights on the mode annunciator panel. The pitch trim servo is used to reduce automatically the load on the stabilizer servo when the autopilot is engaged. The action of the trim servo is monitored to detect a run-away condition. The autopi'ot modes are:

- Pitch Attitude Hold
- Go-Around
- Control Wheel Steering (CWS)
- Altitude
  - Altitude Hold
  - Altitude Arm
- Vertical Navigation (VNAV)
- Wings Level
- Heading Hold
- Heading Select
- Navigation (NAV)
- Approach
  - Glideslope
  - Lateral Beam Following

The modes which follow the radio signals of VOR, RNAV, localizer, and glideslope have submodes for arm, capture, and track of the beam. The heading hold, heading select, navigation, and approach modes provide automatic transition as a navigation or localizer beam is captured. Automatic transitions from vertical navigation, go-around, and altitude select to altitude hold are also mechanized. The autopilot and flight director revert to heading hold and pitch attitude hold if no modes are selected.

The mode switching logic interprets inputs from the pilot and status signals from the system components to select the proper pitch and roll calculations. Yaw damping and flight director signals are provided whenever the autopilot is engaged. The mode logic directs faders on pitch and roll commands to eliminate bumps upon engagement of the autopilot servos.

5.1.1 Autopilot/Flight Director Controls and Displays

Autopilot/Flight Director controls and displays are indicated on Figure 13.

The Autopilot/Flight Director modes are managed via the modified KMC 340 Mode

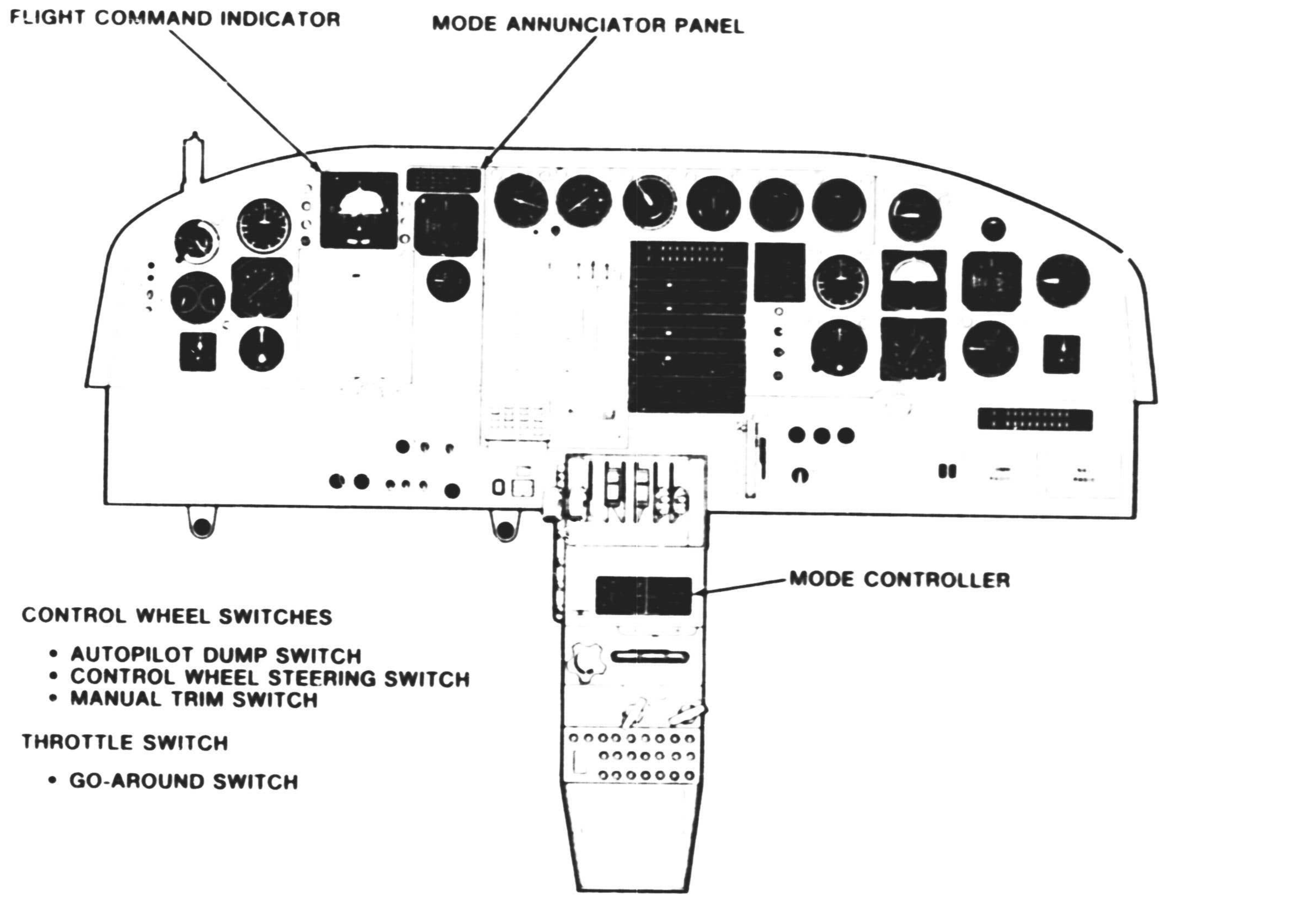


Figure 13. Autopilot Flight Director Controls and Displays

Controller and miscellaneous special switches. Modes are annunciated on the KAP 315 Annunciator Panel. Flight commands are displayed on the KCI 310 Flight Command Indicator.

5.1.1.1 KMC 340 Mode Controller (Figure 14) — The following mode control functions are performed using the KMC 340 Mode Controller:

- Flight director engage
- Yaw damper engage
- Autopilot engage
- Heading select (Variable 1-25 deg/sec)
- Pitch attitude trim (1 deg/sec)
- Approach mode engage
- Nav engage
- Altitude Hold engage
- Altitude ARM engage
- VNAV engage

The switches at the right are the primary engage switches which are used to engage or disengage the flight director, autopilot, and yaw damper. The flight director switch is a momentary contact type which is used to toggle the engage state between on and off. The autopilot and yaw damper switches are solenoid held toggle switches.

With the autopilot engaged and none of the above modes selected, the autopilot will be in the attitude hold and heading hold modes.

The heading is selected by means of the knob located at the left of the mode controller. Rotating the knob to either the left or right precesses the heading select bug on the EHSI at a rate proportional to the knob deflection. The selected heading is read out on the EHSI.

This same knob is used to alter the pitch axis reference (pitch attitude trim). Moving the knob in the longitudinal direction causes the pitch reference to change at a one degree of attitude per second rate. The knob is also effective in altering the altitude reference in the altitude hold modes.

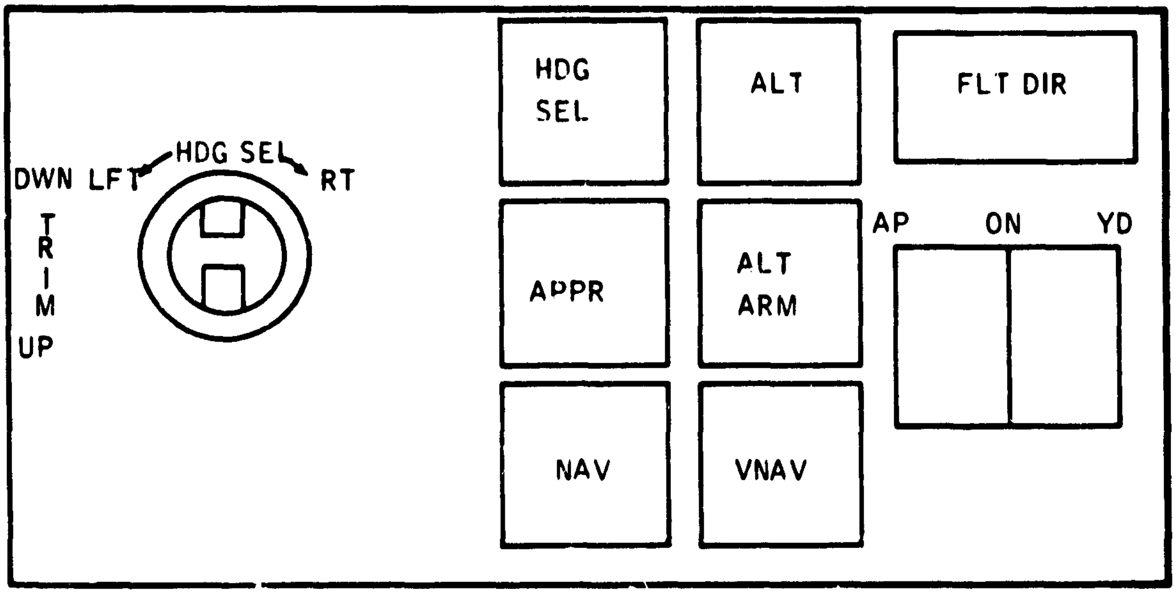


Figure 14. Autopilot-Flight Director Mode Controller

The switches in the center of the panel are push button mode select switches. Pushing the buttons will toggle the state of the mode between the engaged and disengaged state.

5.1.1.2 Special Switches — Four switches alter the state of the system. These momentary contact switches are called —

- autopilot dump switch (on the control wheel)
- control wheel steering switch (on the control wheel)
- go-around switch (on the throttle)
- manual electric trim switch (left side of the control wheel)

A diagram of the autopilot dump switch is shown in Figure 15. Depressing the button disconnects the power to the pitch trim servo. This also energizes the autopilot dump relay which then opens the power source switch to the mode controller. This signal disables the autopilot engage switch holding solenoid, causing the autopilot paddle switch to drop, disengaging the autopilot. The autopilot dump switch energizes a relay to open the power source to the solenoid (this is not shown in Figure 15), and that signal disables the solenoid to drop the yaw damper paddle switch.

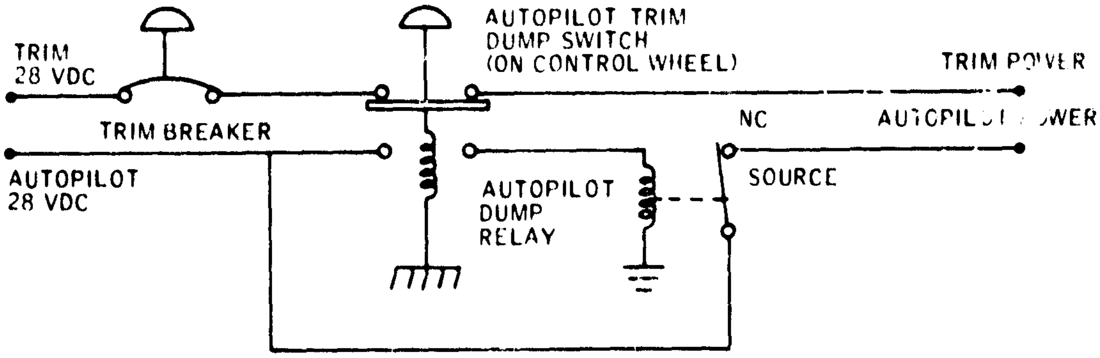


Figure 15. Autopilot Dump Switch

The go-around switch causes the autopilot paddle switch to drop by disabling the solenoid. The autopilot flight director computation is put in the go-around mode which calls for wings level and a preassigned pitch attitude hold. The yaw damper remains on.

The manual electric trim switch also causes the autopilot to disengage, but does not disengage the yaw damper. It runs the pitch trim motor directly.

The control wheel steering switch disengages the pitch and roll servos through the software by removing the pitch and roll engage signals. Two signals are required to engage these servos. The signals just mentioned, which are controlled by the software, and the servo engage signals from the paddle switches on the mode controller. This allows the control wheel steering switch to disengage the servos temporarily without dropping the paddle switches. Upon release of the switch, the servos are again engaged. If pitch attitude hold is on, the synchronizing register follows the pitch angle of the aircraft so the autopilot will hold to the new attitude when the switch is released.

5.1.1.3 KAP 315 Mode Annunciator Panel (Figure 16) — The status of the system is reported by lights set by the computer on the mode annunciator panel. The following states are indicated:

- flight director on
- autopilot on
- yaw damper on
- navigation mode armed
- navigation mode coupled
- heading select mode on
- altitude arm mode on
- altitude hold mode on
- vertical navigation mode on
- glideslope coupled

- approach mode armed
- approach mode coupled
- go-around mode engaged
- reversed localizer on

FLT DIR	YAW DAMP	AUTOPILOT	TRIM FAIL
NAV ARM	HDG SEL	VNAV ARM △1	ALT ARM
NAV CPLD	APPR ARM	VNAV CPLD	ALT HOLD
REV LOC	APPR CPLD	GS CPLD	GO AROUND

△1 Not used in current mechanization

Figure 16. Autopilot/Flight Director Annunciator Panel

5.1.1.4 KCI 310 Flight Command Indicator — The KCI 310 Flight Command Indicator displays the following information:

- Pitch and roll attitude
- Pitch and roll commands
- LOC deviation
- Glideslope deviation
- VNAV flight deviation
- Minimum descent altitude (MDA)
- Decision height (DH)
- Skid/slip on inclinometer

The Flight Command Indicator is shown in Figure 17.

5.1.2 Autopilot/Flight Director Algorithms

Autopilot/Flight Director algorithms described below include:

- Mode logic
- Control laws
- Monitoring functions

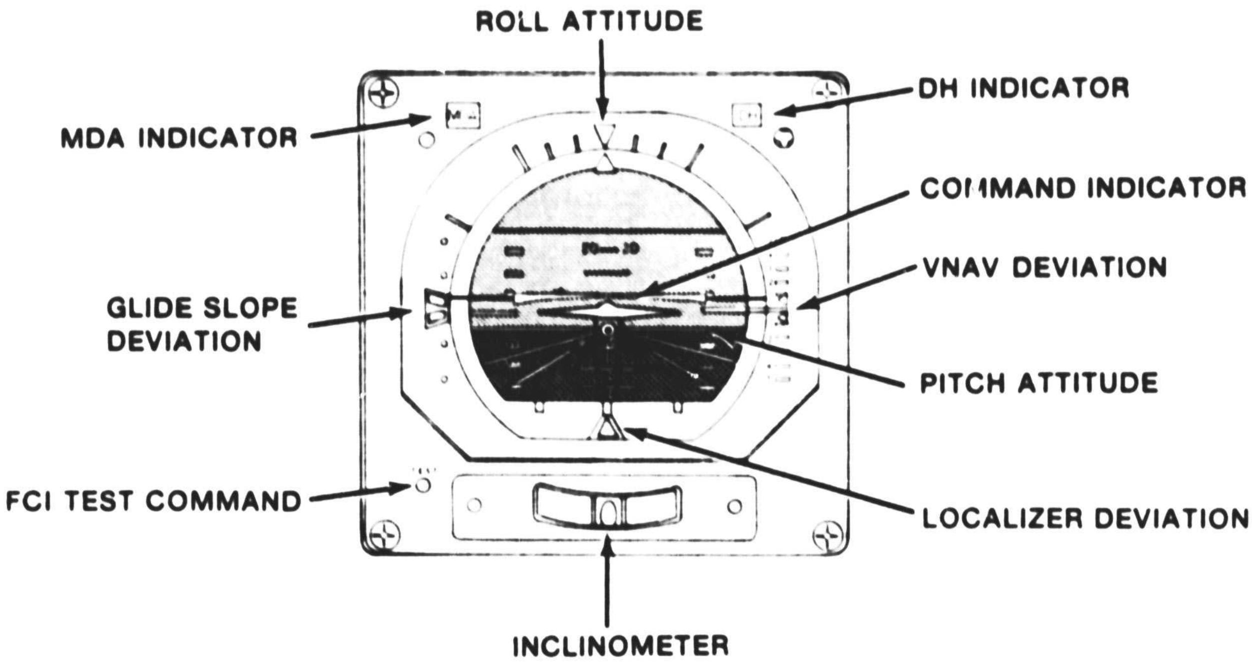


Figure 17. KCI 310 Flight Command Indicator

5.1.2.1 **Autopilot/Flight Director Mode Logic** — The autopilot/flight Director mode logic may be described as a hierarchy of finite-state machines as diagrammed in Figure 18. This decomposition permits an organization of the details and a precise representation of the relations. The lateral and pitch mode logic machines control the autopilot flight director calculations. Several of the modes (states) of these machines have submachines for arm, capture, and track submodes. A diagram of the machines is shown in Figure 19.

5.1.2.1.1 **The System-State Machine** — This machine performs the tasks of the system switch configuration, representing the states of the flight director, the yaw damper, and the autopilot. The state table is recorded in Figure 20. The entries in the body of the tables show the new state to which the system transitions when a given event occurs. All states and events are independent. Dashes indicate "don't care" conditions.

The state transitions are controlled by the:

- flight director button
- yaw damper engage signal
- go-around switch
- autopilot engage signal
- control wheel steering switch

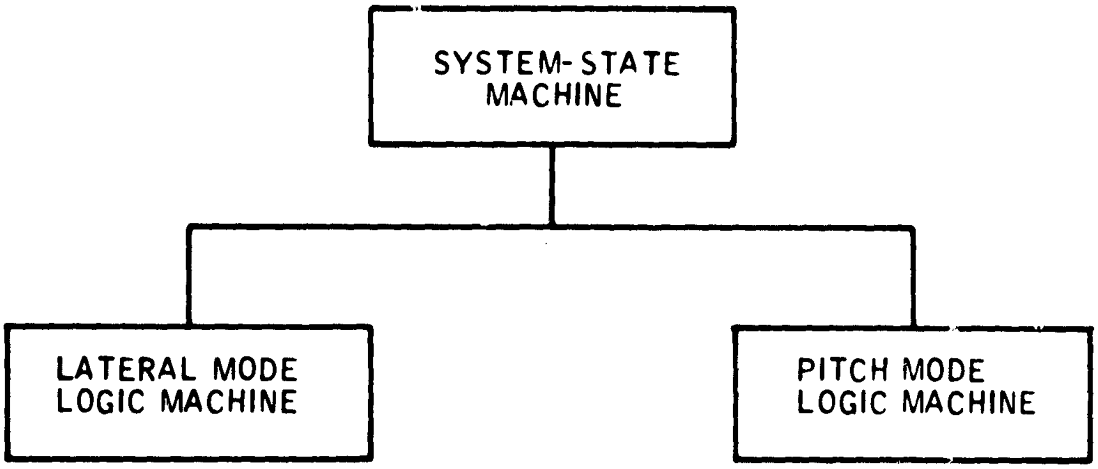


Figure 18. Abstract Machine Hierarchy

The definition of the system-state machine takes into account the mechanization in hardware. The pertinent points are:

- The yaw damper switch and the autopilot switch are mechanically linked so that turning on the autopilot switch carries the yaw damper switch; turning off the yaw damper switch carries the autopilot switch.
- The events listed below must act through the solenoid enables of the autopilot and yaw damper switches:

	YAW DAMPER	AUTOPILOT
go-around switch **on**	---	disable
manual electric trim **on**	---	disable unless CWS
autopilot dump switch **on**	disable	disable
not vertical gyro valid	disable	disable
not trim monitor ok	---	disable
not BIT reports ok	disable	disable

- The flight director must be on before the autopilot may be turned on.
- If the conditions for a service are not met when the service is requested, the request is ignored.

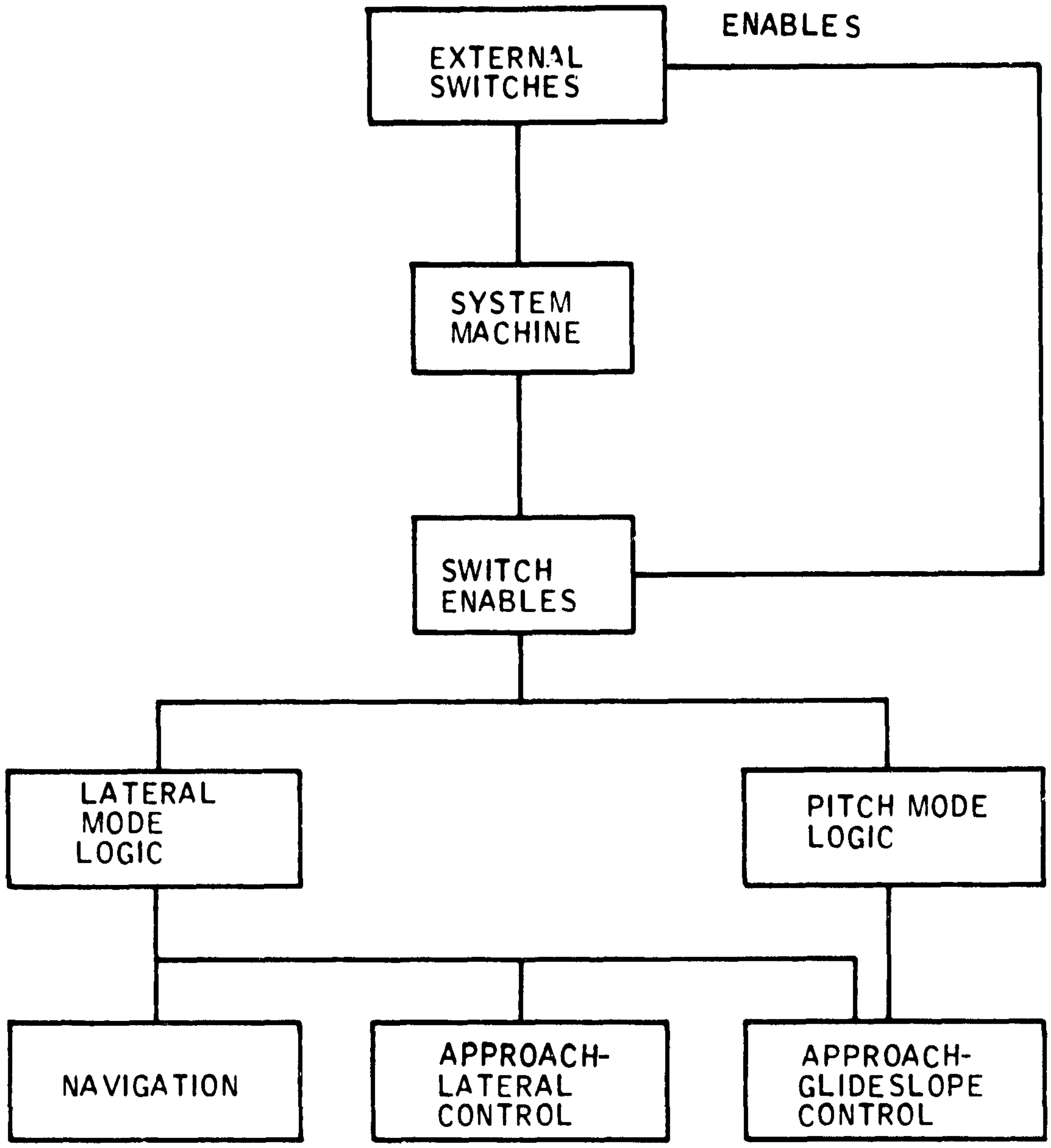


Figure 19. The Software Machines

State \ Event	Flight director flag false	Flight director button in and flight director flag true	Go-around switch on and flight director flag true	Control wheel steering switch on and flight director flag true	Control wheel steering switch off	A mode switch on and flight director flag true (and not FD)	Yaw damper engaged true and yaw damper flag true	Yaw damper engaged false or yaw damper flag false	Autopilot engaged true and autopilot flag true	Autopilot engaged false or autopilot flag false	Starting State 0 •Initiate 2.5 second fade-on ramp ( )Transition is mechanically enforced -Flash autopilot light four times and sound warning horn. ‡CWS alters the flight director output.
0 Flight Director Off Yaw Damper Off Autopilot Off	0	1	1	1	0	1	2	-	0	-	Bias FCI bars out of view
1. Flight Director On Yaw Damper Off Autopilot Off	0	0	1	1•	1•	-	3	-	1	-	Flight director lighted
2 Flight Director Off Yaw Damper On Autopilot Off	0	3	3	3	2	3	-	0	2	-	Bias FCI bars out of view yaw damper lighted, yaw damper enabled
3. Flight Director On Yaw Damper On Autopilot Off	0	2	3	3‡	3‡	-	-	1	4•	-	Flight director lighted, yaw damper lighted, yaw damper enabled
4. Flight Director On Yaw Damper On Autopilot On	0-	4	3+	5	-	-	-	(1)-	-	3-	Flight director, yaw damper and autopilot lighted. Yaw damper, autopilot enabled engage autopilot servos (CWS)
5. Flight Director On Yaw Damper On Autopilot On Control Wheel Steering On	0	5	3-	-	4•	-	-	(1)+	-	3-	Flight director, yaw damper and autopilot lighted. Yaw damper, autopilot enabled disengage autopilot servos (CWS)

Figure 20. Software System Machine

The conditions above may be abbreviated by the following flags:

yaw damper flag = **not** autopilot dump switch on **and** vertical gyro valid **and** BIT reports ok

autopilot flag = yaw damper flag **and not** go-around switch on **and** (**not** manual electric trim on **or** control wheel switch on) **and** trim monitor ok

These flags must be true for the yaw damper and the autopilot to be enabled, respectively.

For the flight director to be enabled, the flight director flag

Flight director flag = vertical gyro valid **and** BIT reports ok,

must be true.

Excessive normal acceleration, as indicated by the g-dump signal, also causes autopilot disengagement. Monitoring included in "BIT Reports OK" and "Trim Monitor OK" are defined in paragraph 5.10.

The system state machine is started with flight director, yaw damper, and autopilot in State 0, and yaw damper and autopilot enabled. The flight director switch and the other mode switches have momentary contact action. The software must look for an off period before it can interpret the signal as a new command. This sort of thing has not been modeled in the finite-state machine representations.

5.1.2.1.2 **The Lateral Modes** — Autopilot/Flight Director lateral modes are:

- Roll damping, Wings Level
- Heading Hold
- Heading Select
- Navigation (NAV)
- Approach

In addition to these separate modes, the system may be in heading hold or heading select with either navigation or approach armed. The mode then automatically switches from heading hold or heading select to navigation or approach when the respective beam is captured.

Roll Damping, Wings Level — These are basic signals which are components of all of the lateral modes. They are the only signals computed for the lateral axes when the pitch axis is in go-around or when the compass is not valid.

Heading Hold — This is the lateral mode to which the system reverts when none of the modes controlled by the buttons has been selected. The compass heading at the time of entry to this mode is the heading automatically held.

Heading Select — A desired heading can be preselected or adjusted by positioning the heading bug on the EHSI (electronic horizontal situation indicator). This is done with the heading select knob on the Mode Controller. The command indicator will deflect in the direction of the shortest turn to satisfy the command, or if the autopilot is engaged, the aircraft will automatically bank-turn to, rollout, and hold the preselected heading. As the selected heading is achieved, the command indicator will command a rollout to hold that heading.

With the heading select mode in operation, subsequent changes indicated in the heading "bug" position on the EHSI will immediately cause the command bars on the flight command indicator to call for a turn to the new heading, unless the heading select button on the mode controller has been depressed again to cancel the heading select mode.

The heading select mode is cancelled when NAV or approach coupling occurs.

Navigation — The NAV mode provides bank commands to intercept and track a VOR course or an RNAV course.

Operation of the navigation mode requires the pilot to proceed as follows:

1. Enter the frequency of the selected VOR (or VORTAC) station on the IDCC.

2. Set the desired course on the IDCC.

3. Depress the NAV button on the mode controller.

When the NAV button on the mode controller is depressed, navigation arm will be lighted on the annunciator panel and the automatic capture logic is armed, provided a

valid VOR or VORTAC signal is being received. Heading hold and heading select, if operating, are retained until capture occurs. However, if navigation track conditions are true when NAV is selected, the system will start in the NAV capture mode.

If the NAV mode is selected with the wings level within ±4° of bank and within three dots of course deviation, NAV arm will be bypassed and NAV coupled will engage directly.

Transition from capture to track is made through a track armed state. This is entered from capture when a bank greater than 5 degrees is made. Then the track mode is engaged when the navigation beam track flag becomes true.

The VOR or RNAV "course-capture" point is variable to prevent overshoot and depends on distance, angle of intercept, and speed of capture. Upon capture, a bank command will be introduced on the FCI, the heading select, if on, will be cancelled, and the NAV coupled will be lighted on the Annunciator Panel.

The pilot can manually bank the aircraft to satisfy the command bars which will call for a rollout to wings level when on course. Crosswind compensation is provided as necessary to track course.

If the Autopilot/Flight Director is engaged, the aircraft will bank to satisfy the command display and rollout on course automatically.

The NAV mode is cancelled by depressing the navigation button or selecting heading select or approach modes.

Approach — The approach mode provides bank and pitch commands to capture and track precision ILS (LOC and Glideslope) beams or non-precision VOR or RNAV courses.

Operation of the approach mode requires the pilot to —

1. Enter the navigation receiver frequency on the IDCC

2. Enter the course to the runway heading or approach front course on the IDCC

3. Depress the approach button on the mode controller

The automatic approach function will be immediately armed (provided NAV receiver and/or RNAV computer signals are valid). "Approach Arm" will be lighted on the mode annunciator panel.

In approach arm mode, the controlling mode is retained until capture. This allows the pilot to adjust the heading to approach control vectoring instructions.

The LOC beam or VOR/RNAV "capture" point will vary depending on IAS, angle of intercept, and rate of closure. Upon capture, a bank command will be introduced on the FCI, the existing heading mode will be cancelled, and "Approach Coupled" will be lighted on the annunciator panel.

The pilot may manually bank the aircraft to satisfy the command bars which will command a rollout to wings level when the aircraft is on course. Automatic crosswind compensation will provide precise tracking. RNAV/VOR/LOC deviation is shown on the EHSI, and actual crab angle will be shown by offset of the course arrow from the aircraft symbol.

Throughout a precision approach, LOC deviation is displayed on both the FCI and EHSI. Glideslope deviation is displayed on the FCI.

If the autopilot is engaged during operation in the approach mode, automatic steering response will follow the command display on the FCI.

Whenever a LOC frequency is selected and the aircraft intercepts the LOC course at an angle greater than 90° from the inbound front course, the REV LOC mode is automatically activated. The LOC receiver signals are reversed to permit the FCI steering command display to operate on a fly-to rather than a fly-from basis on the reverse course. "REV LOC" is automatically lighted on the annunciator panel.

When capturing the localizer at an angle greater than 90° to the front course, the system will command flying outbound on the front course or inbound on the back course.

Operation on REV LOC is identical to front course operation, except that automatic glideslope capture is "locked out" by the switching logic.

The switching of the lateral modes is modeled by the finite-state machine in Figure 21. The submachines for navigation and approach-lateral control are integrated in the lateral mode logic machine.

5.1.2.1.3 The Pitch Modes — Autopilot Flight Director pitch modes include:

- Pitch damping, up elevator
- Pitch attitude hold
- Go-around
- Altitude hold
- Altitude select
- Altitude capture
- Vertical navigation
- Glideslope
- Control wheel steering

Altitude select may be used with either pitch attitude hold, vertical navigation, or go-around. Upon approaching the selected altitude, the system will automatically switch into a capturing transition mode, and on engaging the selected altitude, will switch to altitude hold. The control wheel steering function, which has been included as a system state, is described in this section.

Pitch Damping, Up-Elevator — These are basic commands that are continuously computed regardless of the modes of the system.

Pitch Attitude Hold — When no special pitch mode has been selected, the system reverts to this mode.

Go-Around — The Go-Around mode assists the pilot in establishing the proper pitch attitude under missed-approach conditions. The go-around switch is located on the control wheel.

Depression of the go-around switch cancels all other modes and disengages the autopilot, if it is engaged. A wings-level and nose-up command is displayed by the FCI and Go-Around is lighted on the annunciator panel. The magnitude of the nose-up command is adjusted for each aircraft model.

State \ Event	1 Flight director off	2 Go-around on	3 Not compass valid	4 Control wheel steering switch on	5 Roll angle ≤ 4 degrees	6 Heading select button on	7 Navigation button on and navigation beam track true	8 Navigation button on and navigation beam track false	9 Approach button on and lateral beam track true	10 Approach button on and lateral beam track false	11 Not VOR/LOC/RNAV valid	12 Roll angle ≥ 5 degrees	13 (Navigation beam capture and not RNAV mode on) or RNAV capture true	14 Lateral beam capture true	15 Navigation beam track true	16 Lateral beam track true	17 NAV sequence true	Starting State 1 *CWS alters the flight director output
0. Wings Level	0	0	0	0	-	5	8	3	11	4	-	-	-	-	-	-	-	
1. Wings Level and Heading Hold Arm	1	0	0	1	2	5	8	3	11	4	-	-	-	-	-	-	-	
2. Heading Hold	1	0	0	2*	-	5	8	3	11	4	-	-	-	-	-	-	-	
3. Heading Hold and Navigation Arm	1	0	0	3*	-	6	1	1	11	4	1	-	8	-	-	-	-	Navigation arm lighted
4. Heading Hold and Approach Arm	1	0	0	4*	-	7	8	3	1	1	1	-	-	11	-	-	-	Approach arm lighted
5. Heading Select	1	0	0	5	-	1	8	6	11	7	-	-	-	-	-	-	-	Heading select lighted
6. Heading Select and Navigation Arm	1	0	0	6	-	3	5	5	11	7	5	-	8	-	-	-	-	Heading select lighted and navigation arm lighted
7. Heading Select and Approach Arm	1	0	0	7	-	4	8	6	5	5	5	-	-	11	-	-	-	Heading select lighted and approach arm lighted
8. Navigation Capture	1	0	0	1	-	5	1	1	11	4	1	9	-	-	-	-	3	Navigation coupled lighted
9. Navigation Capture and Track Arm	1	0	0	1	-	5	1	1	11	4	1	-	-	-	10	-	3	Navigation coupled lighted
10. Navigation Track	1	0	0	1	-	5	1	1	11	4	1	-	-	-	-	-	3	Navigation coupled lighted
11. Approach Capture	1	0	0	1	-	5	8	3	1	1	1	12	-	-	-	-	4	Approach coupled lighted
12. Approach Capture and Track Arm	1	0	0	1	-	5	8	3	1	1	1	-	-	-	-	13	4	Approach coupled lighted
13. Approach Track	1	0	0	1	-	5	8	3	1	1	1	-	-	-	-	-	4	Approach coupled lighted

Figure 21. Lateral Mode Logic Machine

The go-around mode may also be used on takeoff for climbout attitude guidance. When used for takeoff, it may be followed with heading select for continuous heading control during departure. Altitude, NAV, and approach modes may also be armed for automatic capture and guidance during the departure sequence.

The go-around mode is disengaged by the selection of altitude, VNAV, altitude arm, and vertical trim; the autopilot can be engaged with the go-around mode active.

Altitude Hold — This mode will cause a computed pitch command to hold the aircraft at the pressure altitude existing at the time it was activated.

The mode is activated either automatically by the altitude capture function, or manually by depressing the altitude button on the mode controller.

If the autopilot is engaged, it will automatically hold the aircraft at that altitude.

The vertical trim switch may be used to adjust the selected altitude up or down at a constant rate of 500 feet per minute without disengaging the mode. This enables the pilot to conveniently adjust the aircraft altitude to match resetting of the altimeter or to make short descent segments during a nonprecision approach.

The altitude hold mode is cancelled by automatic glideslope capture or select of the altitude select, VNAV, or go-around modes.

Altitude Arm — This mode allows the pilot to select an altitude and upon approaching that selected altitude, obtain an automatic pitch command to capture and hold the pre-selected altitude. To operate in this mode the pilot must proceed as follows:

1. Enter the desired altitude on IDCC.
2. Establish a climb or descent as appropriate.
3. Depress the altitude arm button on the mode controller. This may be done at any time during the climb or descent before the selected altitude has been attained.

As the aircraft approaches the selected altitude, the pitch rate command will automatically guide the pilot through it at a low rate. As the aircraft reaches the selected altitude, altitude hold will automatically engage and light on the annunciator panel and altitude arm will disappear. The command bars on the FCI will call for level flight at the selected altitude.

Altitude arm is disengaged by depressing the altitude arm button, by engaging altitude hold, and by glideslope capture.

Altitude Capture — This provides the transition from altitude select to altitude hold.

VNAV — The VNAV mode provides computed pitch commands to capture and maintain a vertical track, in ascent or descent, to a predetermined altitude with respect to an RNAV waypoint (which can be over a VORTAC). To operate in this mode, the pilot must proceed as follows:

1. Enter a receivable VORTAC frequency on the IDCC.
2. Establish an RNAV waypoint on the IDCC and select RNAV mode.
3. Establish the course to the waypoint.
4. Set the desired altitude over the waypoint on the IDCC.
5. Set along-track bias to reach desired altitude offset along course from the waypoint.
6. Set the approximate VORTAC station elevation to obtain slant range correction.

The vertical track angle will then be displayed on the EHSI. As the aircraft flies toward the waypoint at a constant altitude, the vertical track angle (VTA) will slowly increase or decrease. When the desired vertical track angle is indicated on the display scale, the pilot engages vertical navigation guidance by depressing the vertical navigation button on the mode controller. The autopilot/flight director will then control the aircraft in the vertical plane to fly a straight path from engage point to the preselected waypoint altitude at the offset position.

VNAV coupled will be lighted on the annunciator panel, the vertical track angle indicated on the EHSI display scale remains the VTA, and the display ADI scale pointer displays the altitude deviation in feet from the selected vertical flight path.

The FCI command bars will deflect to command the pitch up or pitch down maneuver to acquire and hold the flight path.

Engagement of the VNAV coupled mode also automatically activates the altitude select function to capture the selected altitude. As the aircraft approaches the selected altitude, a pitch rate command will automatically guide the pilot through it at a low rate. As the aircraft reaches the selected altitude, vertical navigation coupled will

automatically disengage and altitude hold will automatically engage, altitude hold will light on the annunciator panel, and altitude select will disappear. The command bars on the FCI will call for level flight at the selected altitude.

If the autopilot is engaged, capture and holding of the vertical track angle and subsequent capture and holding of the desired altitude will be automatic. Adjustment of power will have no effect on the vertical track angle but will affect the indicated airspeed and vertical speed.

Waypoint distance bias is provided to permit the pilot to acquire a desired altitude at a point short of the waypoint. For example, the waypoint could be established at a runway threshold with the desired MDA altitude selected and the waypoint distance biased 1 to 2 miles short to position the aircraft for a straight-in approach. Waypoint bias adjustment should not be made while VNAV is coupled. Power is controlled by the pilot during ascent or descent.

The VNAV coupled mode is deactivated by selection of any other vertical mode or by pushing VNAV.

Glideslope — The glideslope mode is armed for automatic capture when LOC front course capture has occurred. Automatic glideslope capture occurs as the aircraft approaches the beam from above or below.

Upon capture of the glideslope beam, "glideslope coupled" is lighted on the annunciator panel and a capture command is displayed by the command bars. The pilot (or autopilot) controls the aircraft to satisfy the command bars.

Upon glideslope capture, altitude hold is cancelled. However, altitude hold may be manually reselected to maintain altitude upon descent to MDA or DH if visual contact is not established.

During VOR or RNAV approaches, glideslope capture will not occur because the absence of LOC frequency locks out this function.

The approach coupled mode is cancelled by selection of the heading select, NAV, or go-around modes.

Control Wheel Steering — Control Wheel Steering (CWS) provides the pilot with the capability for manual maneuvering of the aircraft without the need to disengage and reengage the autopilot.

The CWS mode is engaged by continuous pressure on the CWS button. Operation of the CWS button causes immediate release of autopilot servos and allows the pilot to assume manual control, while autopilot control functions and all engaged modes, except heading select, VNAV, navigation, and approach, are placed in a synchronization state.

This means that all modes, except heading select, VNAV, NAV, and approach, remain in continuous synchronization with the pilot's aircraft maneuvers so that upon release of the CWS mode button, all previously engaged modes will smoothly reassume control of the aircraft unless decoupled or reprogrammed by the pilot.

When in navigation or approach after the CWS button is released, the aircraft will revert to heading hold. If in altitude hold, the aircraft will hold that altitude which was present upon release of the CWS switch. When in VNAV the aircraft will revert to pitch altitude hold.

Since all engaged modes remain coupled (in synchronization) during operation of the CWS mode, their annunciator lights will continue to show on the annunciator panel. The CWS mode is not separately annunciated.

The transitions of the modes of pitch axis are specified in Figure 22. The glideslope machine is armed from the approach-lateral control machine when the lateral beam is captured and the approach is not on the backcourse of the localizer.

5.1.2.2 Autopilot/Flight Director Control Laws — The Autopilot/Flight Director control laws, described below, are summarized in Figures 23, 24 and 25 for the pitch, roll, and yaw axes. Terms included are discussed in the following paragraphs.

5.1.2.2.1 Base Terms — These terms are always included regardless of the particular modes:

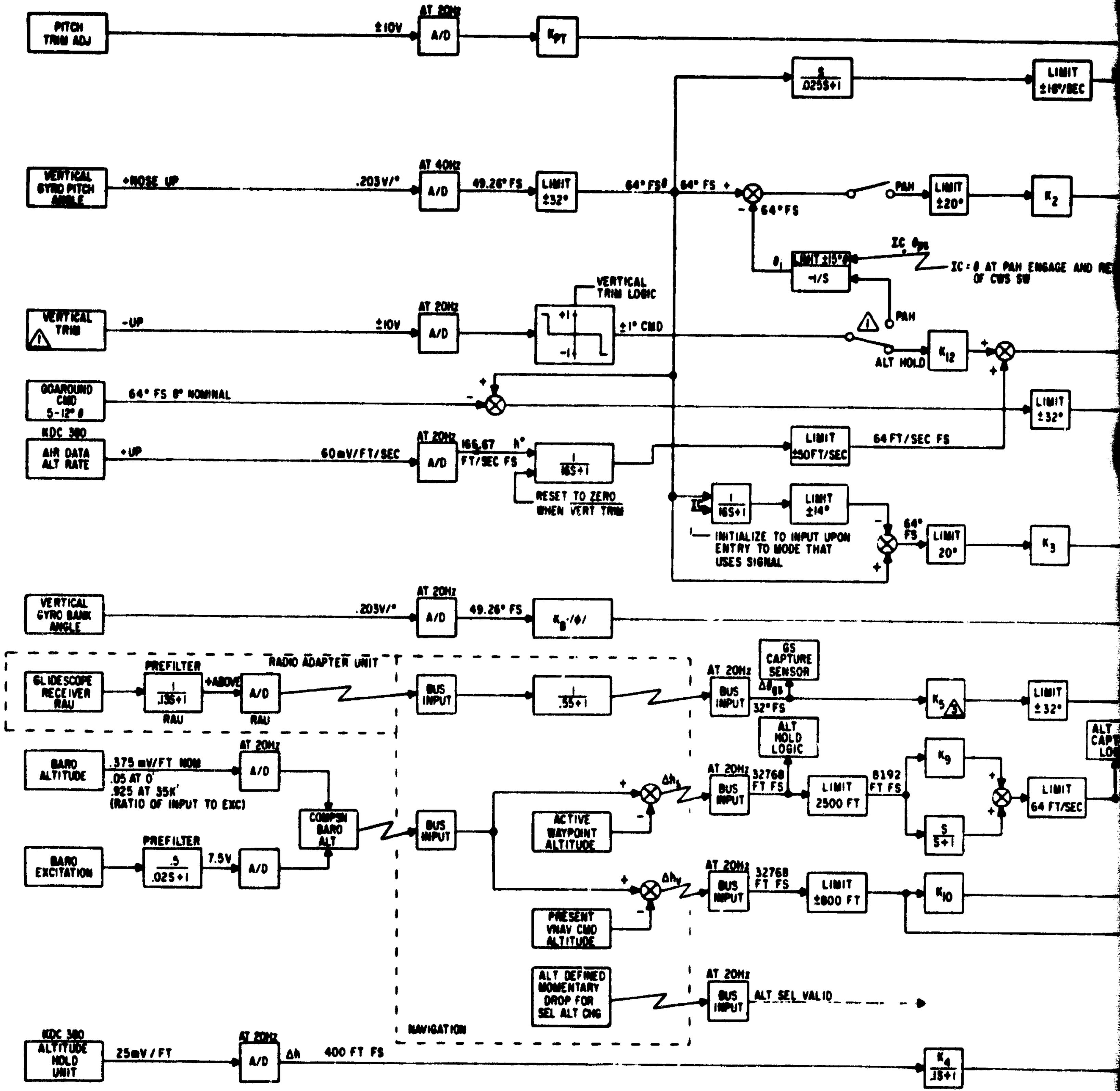
Pitch Damping —

$$\theta_d = \frac{S}{0.025\,S + 1} \cdot \theta$$

State \ Event	1. Flight director off	2. Go-around switch on	3. Control wheel steering switch on	4. Vertical trim on	5. Altitude button on and altitude valid	6. Not altitude valid	7. Altitude arm button on and (altitude valid and altitude select valid)*	8. Not altitude select valid or Not baro altitude valid	9. Vertical navigation button on and VNAV engage valid*	10. Not VNAV valid	11. Lateral machine in an approach mode and glideslope flag true and glideslope engage true	12. Not lateral machine in an approach mode or backcourse true	13. Not glideslope valid	14. Glideslope valid and (glideslope engage true or false)	15. Altitude capture true	16. Altitude engage true	Starting: State 0. †CWS alters the flight director output. Glideslope flag = Loc Valid and not backcourse. VNAV engage valid = VNAV valid and VTA valid
0. Pitch Attitude Hold	0	1	0†	0	2	-	3	-	5	-	7	-	-	-	-	-	
1. Go-Around	0	1	0	0	2	-	4	-	5	-	7	-	-	-	-	-	Go-around lighted
2. Altitude Hold	0	1	2†	2	0	0	3	-	5	-	7	-	-	-	-	-	Altitude hold lighted. Declutch altitude engage on vertical trim or CWS
3. Altitude Select and Pitch Altitude Hold	0	1	3†	3	2	0	0	0	5	-	7	-	-	-	6	-	Altitude arm lighted
4. Altitude Select and Go-Around	0	1	3†	3	2	1	1	1	5	-	7	-	-	-	6	-	Altitude arm lighted and go-around lighted
5. Altitude Select and Vertical Navigation	0	1	0	3	2	0	0	0	3	0	7	-	-	-	6	-	Altitude arm lighted and vertical navigation coupled lighted
6. Altitude Capture	0	1	6†	0	2	0	0	-	6	-	7	-	-	-	-	2	Altitude arm lighted
7. Glideslope Coupled	0	1	0	0	2	-	7	-	7	-	7	0	8	-	-	-	Glideslope lighted
8. Glideslope Standby	0	1	0	0	2	-	8	-	8	-	7	0	-	7	-	-	Flash glideslope light

*And baro altitude valid

Figure 22. Pitch Mode Logic Machine



FOLDOUT FRAME

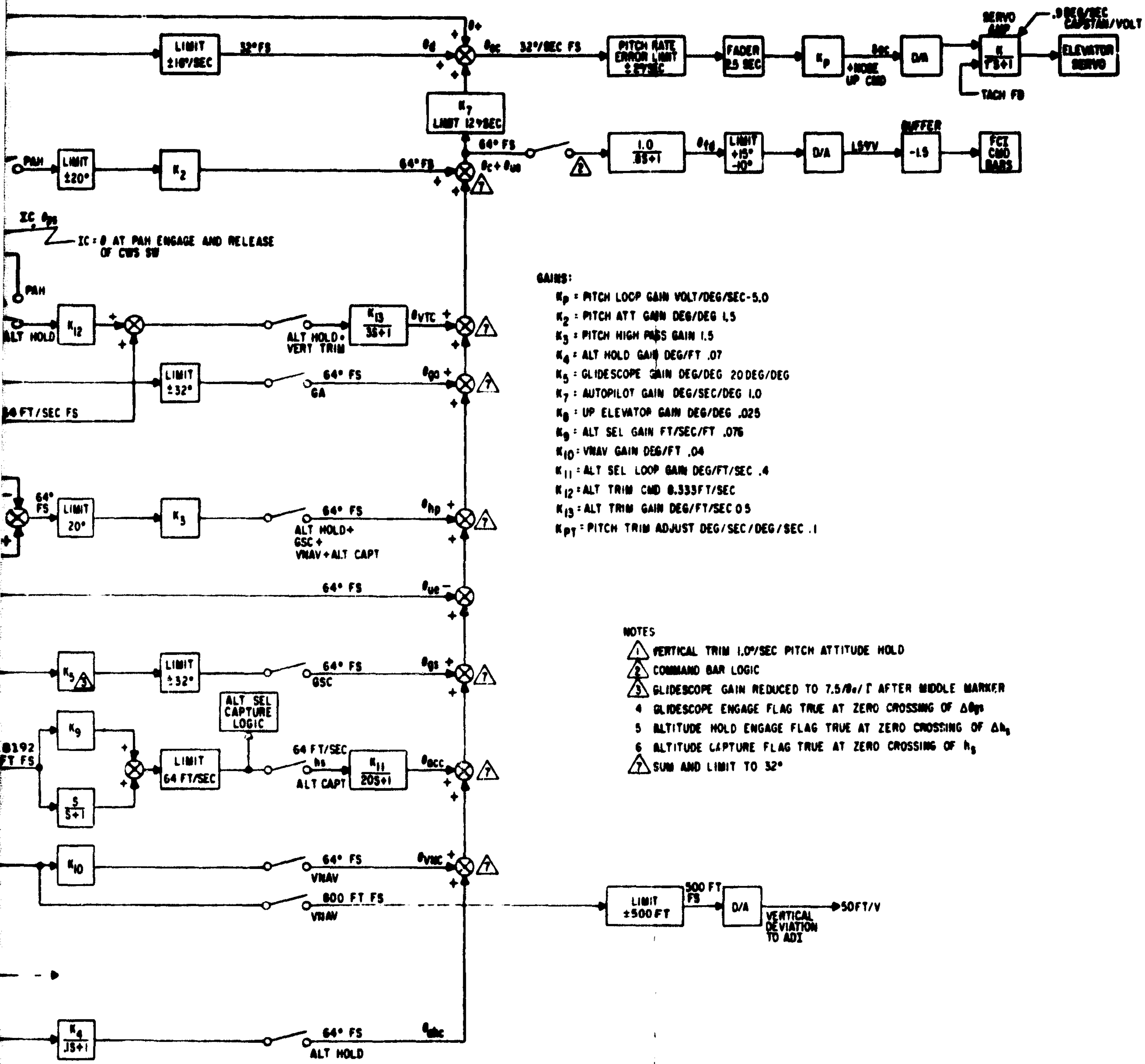
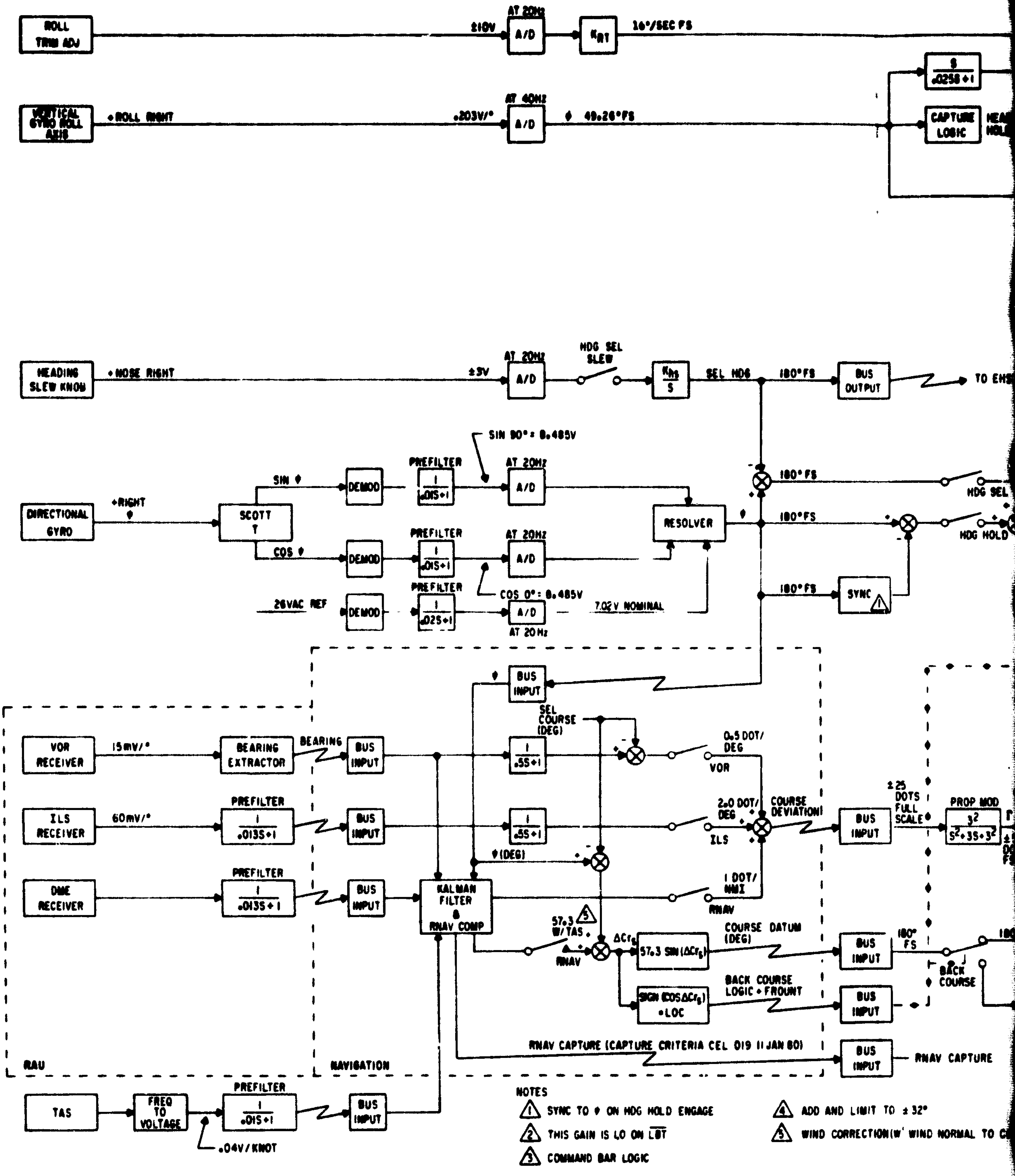


Figure 23. DAAS Control Laws, Pitch Axis

FOLDOUT FRAME 2



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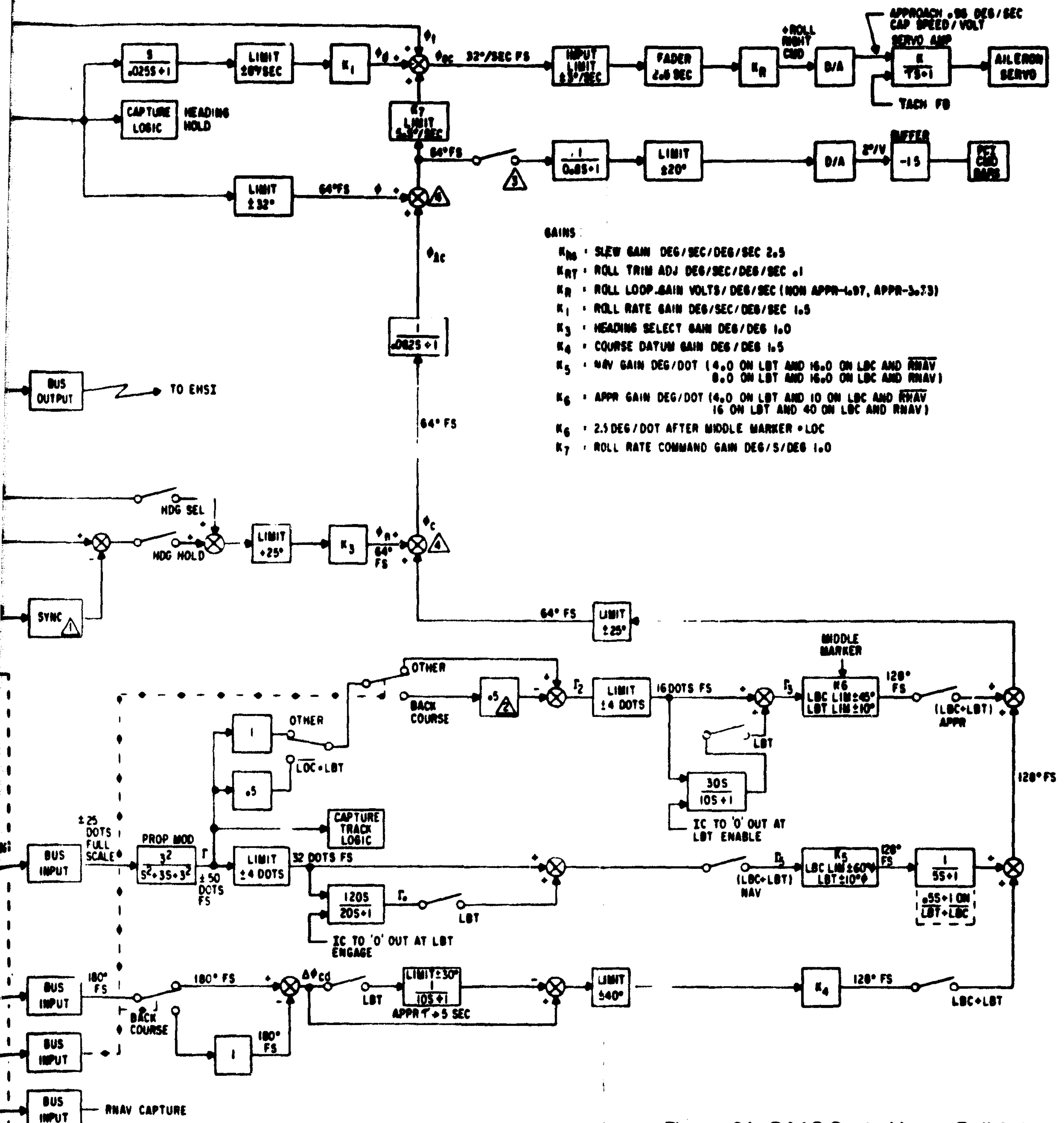

Figure 24. DAAS Control Laws, Roll Axis

D AND LIMIT TO ± 32°

IO CORRECTION (W' WIND NORMAL TO COURSE)

FOLDOUT FRAME 2

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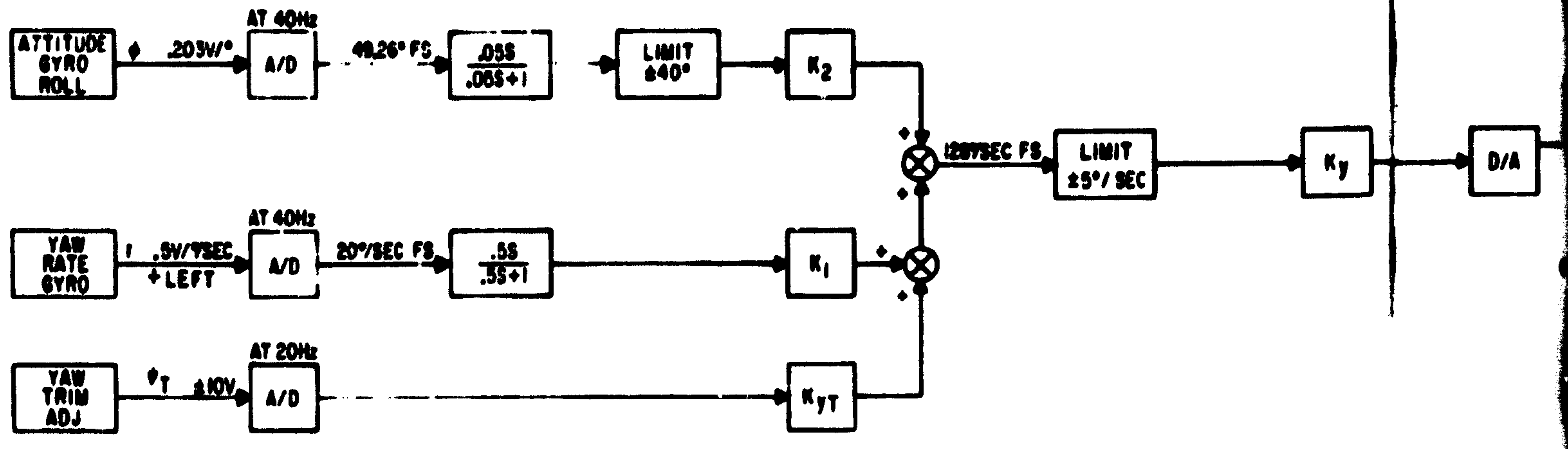
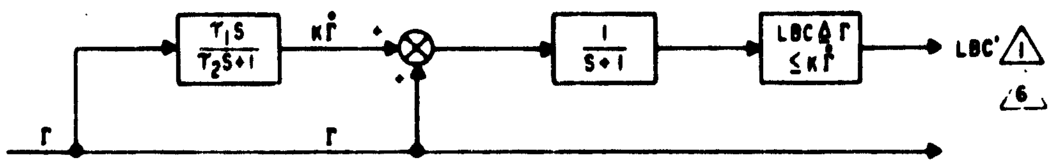
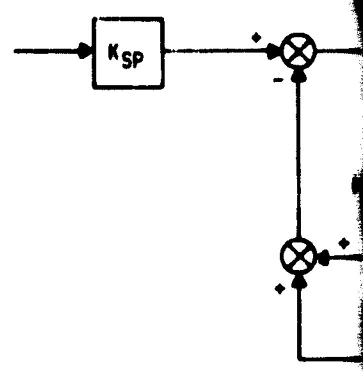


DAAS YAW AXIS

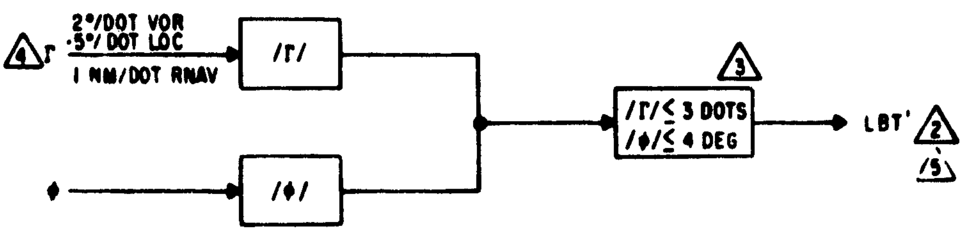
NAV/APPROACH LOOP CAPTURE (VOR - ILS MODES)



NAV $T = 16$, $T_2 = 20$ (NORMALIZED TO V = 200 KNOTS, $\phi_{CD} = 45°$)
APPR $T_1 = 12.75$, $T_2 = 1.75$ (NORMALIZED TO V = 130 KNOTS, $\phi_{CD} = 45°$)

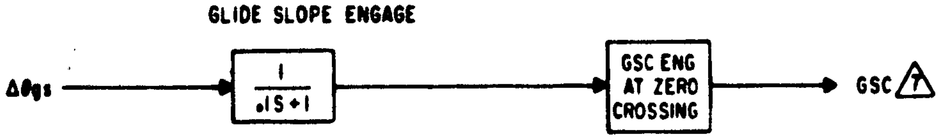


NAV/APPROACH LOOP TRACK



ARMED WHEN LBC $|\phi| \ge 5°$

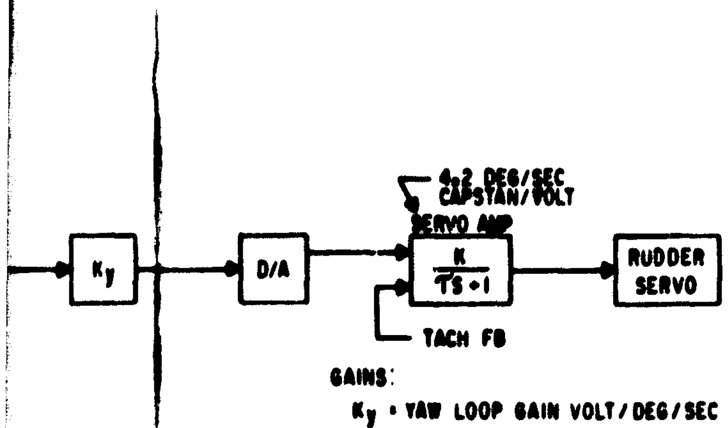
GLIDE SLOPE ENGAGE



NOTES:

1. LBC = (LBC' & Γ ARE OPPOSITE SI… + RNAV CAPTURE
2. LBT = ARM • LBT'
3. RNAV • APPROACH $|\Gamma| \le .75$ DOTS
4. Γ COURSE DEVIATION
5. LBT' LATERAL BEAM TRACK
6. LBC' LATERAL BEAM CAPTURE
7. GSC GLIDE SLOPE CAPTURE

FOLDOUT FRAME



GAINS:

K_y = YAW LOOP GAIN VOLT/DEG/SEC 1.055V/DEG/SEC

K_1 = YAW FORWARD LOOP GAIN DEG/SEC/DEG/SEC 2.0

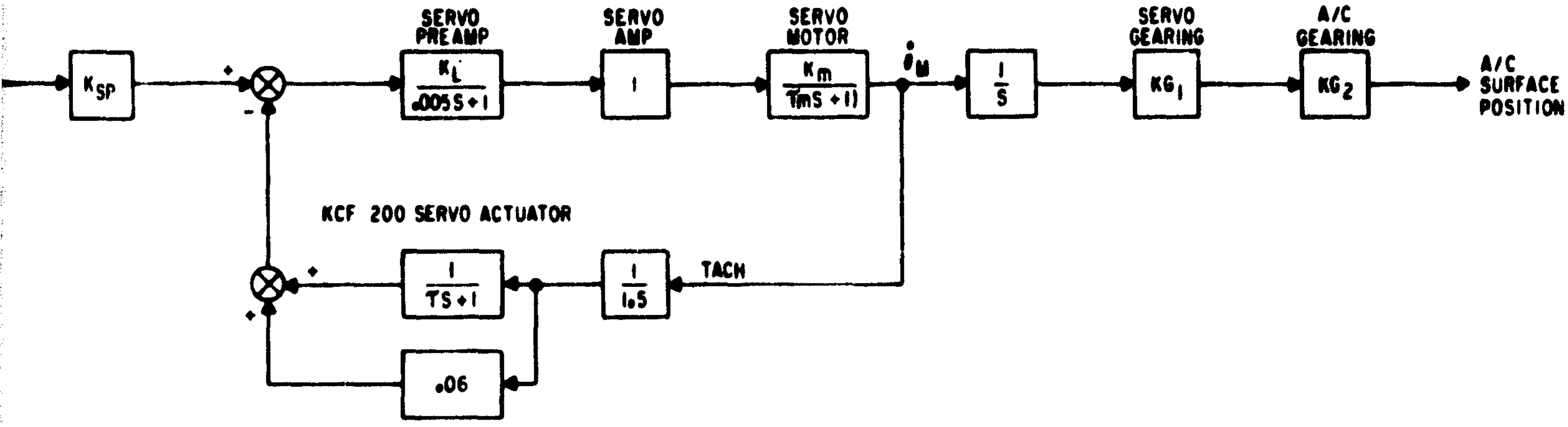
K_2 = ROLL TURN COORDINATION GAIN DEG/SEC/DEG/SEC 2.0

K_{yT} = DEG/SEC/DEG/SEC .05

DAAS YAW AXIS

K_L = 20 PITCH

= 40 ROLL & YAW



T = 0.5

SERVO ACTUATOR CHARACTERISTICS;

MAX TORQUE (CAPSTAN RADIUS = .88 IN) = 200 IN/LBS

NO LOAD SPEED (CAPSTAN) = 12 RPM

GAINS:

K_{SP} = VOLT/VOLT = .45 PITCH

= .32 ROLL (APPROACH)

= .53 YAW

BC = (LBC' & Γ ARE OPPOSITE SIGNS OR LBT' & NAV/APPR DEPRESSED) • $\overline{\text{RNAV}}$

RNAV CAPTURE

BT = ARM • LBT'

NAV • APPROACH |Γ| ≤ .75 DOTS

Γ COURSE DEVIATION

BT' LATERAL BEAM TRACK

BC' LATERAL BEAM CAPTURE

SC GLIDE SLOPE CAPTURE

Figure 25. DAAS Control Laws, YAW Axis and Miscellaneous

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θ = pitch angle shaped by the second-order analog prefilter

$$\frac{1}{S^2/\omega_n^2 + \zeta S/\omega_n + 1}$$

ω_n = 31 rad/sec

ζ = 0.5

Pitch Synchronization —

θ_{ps} = θ at the instant of engaging the pitch attitude hold mode or at release of the CWS switch.

Up-Elevator —

θ_{ue} = $K_8|\phi|$

K_8 = up-elevator gain
= 0.025 deg/deg

ϕ = vertical gyro bank angle. It is shaped by a 0.05-second lag analog prefilter.

Roll Damping —

$$\phi_d = K_1 \cdot \frac{S}{(0.025\ S + 1)} \cdot \phi$$

K_1 = roll rate gain
= 1.5 deg/sec/deg/sec

ϕ = vertical gyro bank angle

Yaw Damping and Turn Coordination — The damping function is achieved by using a high-pass filter on the yaw rate signal to command the rudder servo. A signal to assist in coordinating turns is also summed into the command; it is derived from the roll angle by a high-pass filter.

$$\psi_c = K_y \cdot \underset{(\pm\ 5°/\text{sec})}{\text{limit}} \cdot \left[K_1 \cdot \frac{0.5\ S}{0.5\ S + 1} \cdot r + K_2 \cdot \frac{0.05\ S}{0.05\ S + 1} \cdot \phi\right]$$

with

ϕ = roll angle, degrees. It is shaped by a second order lag analog prefilter with 0.5 damping and 31 radian/second frequency

r = yaw rate, deg/sec

K_1 = yaw rate gain
= 2.0 deg/sec/deg/sec

K_2 = roll turn coordination gain
= 2.0 deg/sec/deg/sec

K_y = yaw axis gain
= 2.0 deg/sec/deg/sec

Note: all factors should be read as operators acting on the quantity to their right.

Output Equations

Flight Director-Pitch —

$$\theta_{fd} = \frac{1}{0.8\,S + 1} \cdot (\theta_c - \theta_{ue})$$

θ_c = pitch mode command
θ_{ue} = up-elevator command

Flight Director-Roll —

$$\phi_{fd} = \frac{1}{0.8\,S + 1} \cdot (\phi_{lc} + \phi)$$

$$\phi_{lc} = \underset{(\pm 25°)}{\text{limit}} \cdot \frac{1}{0.062\,S + 1} \cdot \phi_c$$

ϕ_c = roll mode command
ϕ = roll angle shaped by 0.05 - lag prefilter

Elevator Output Command —

$$\delta_{ec} = K_p * \underset{(2.5\text{ sec.})}{\text{fader}} * \underset{(\pm 2°/\text{sec})}{\text{limit}} \cdot \theta_{oc}$$

K_p = pitch forward loop gain = 5.0 deg/deg/sec

$$\theta_{oc} = \theta_d + K_7 \cdot \underset{(\pm\ 12°)}{\text{limit}} \cdot (\theta_c - \theta_{ue})$$

K_7 = 1 deg/sec/sec

θ_d = pitch damping signal
θ_{ue} = up-elevator command
θ_c = pitch mode command

Aileron Output Command —

$$\delta_{ac} = K_2 \cdot \underset{(2.5\ \text{sec.})}{\text{fader}} \cdot \underset{(\pm\ 3°/\text{sec})}{\text{limit}} \cdot \phi_{oc}$$

K_2 = roll forward loop gain = 0.7 deg/deg/sec

$$\phi_{oc} = \phi_d + K_7 \cdot \underset{(\pm\ 5.5°/\text{sec.})}{\text{limit}} \cdot (\phi_{lc} + \phi)$$

K_7 = roll rate command gain = 1.0 deg/sec/deg

ϕ_{lc} = limited roll mode command

ϕ = wings level command

ϕ_d = roll damping signal

$$\phi_{lc} \quad \underset{(\pm\ 25°)}{\text{limit}} \frac{1}{0.062\ S + 1} \cdot \phi_c$$

ϕ_c = roll mode command

5.1.2.2.2 Pitch Axis Terms

Pitch Attitude Hold —

$$\theta_{pah} = \begin{cases} K_2 \cdot (\theta - \theta i), \text{ in pitch attitude hold} \\ 0, \text{ otherwise} \end{cases}$$

K_2 = pitch attitude gain = 1.5 deg/deg

$$\theta_i = \begin{cases} \underset{(+15^\circ)}{\text{limit}} \cdot \frac{1}{S} \cdot \Delta\theta_T + \theta_{ps}, & \text{in pitch attitude hold} \\ 0, & \text{otherwise} \end{cases}$$

θ_{ps} = pitch synchronization

$$= \begin{cases} \theta, & \text{at the instant of engaging the pich attitude hold mode or at the instant of release of the CWS switch} \\ \theta, & \text{for any other mode including the time the control wheel steering switch is on} \end{cases}$$

$\Delta\,\theta_T$ = vertical trim input command

Vertical Trim Command —

$$\theta_{VTC} = K_{12} * \frac{1}{3.0S+1} \cdot \Delta\theta_T$$

$$\Delta\theta_T = \begin{cases} \left[\dot{h} * \frac{1}{16\,S+1}\right] - K_{12} * VT_{CMD} & \text{for altitude hold} \\ 0, & \text{otherwise} \end{cases}$$

VT_{CMD} = 1 for vertical trim depressed

Go-Around Command —

$$\theta_{gac} = \begin{cases} \theta - \theta_{ga}, & \text{for go-around mode} \\ 0, & \text{otherwise} \end{cases}$$

θ_{ga} = a constant command, 5-12 degrees

High-Passed Pitch Attitude —

$$\theta_{hp} = \begin{cases} K_3 * \underset{\pm 20^\circ}{\text{Limit}} * \left[1 - \underset{\pm 14^\circ}{\text{Limit}} * \frac{1}{16\,S+1}\right] \cdot \theta & \text{for altitude hold, glide slope capture, and standby vertical navigation altitude select} \\ 0, & \text{otherwise} \end{cases}$$

Altitude Select — Altitude select may be on with pitch attitude hold, vertical navigation, or go-around. The capture signal is used only to determine when to switch from the controlling mode to the altitude capture transition. It is computed as:

$$h_s = \begin{cases} \left[K_9 + \dfrac{S}{S+1}\right] \cdot \Delta h_s, \text{ for altitude select} \\ 0, \text{ otherwise} \end{cases}$$

K_9 = altitude select gain = 0.076 ft/sec/ft

Δh_s = navigational computer altitude select command

The altitude capture flag becomes true when $h_s = 0$.

Altitude Capture Command —

$$\theta_{acc} = \begin{cases} K_{11} * \dfrac{1}{20\,S+1} \cdot h_s, \text{ altitude capture} \\ 0, \text{ otherwise} \end{cases}$$

K_{11} = altitude capture loop gain = 0.4 deg/ft/sec

h_s = altitude capture signal

Altitude engage flag becomes true when $\Delta h_s = 0$. This event automatically disengages altitude capture and brings in altitude hold.

Altitude Hold Command —

$$\theta_{ahc} = \begin{cases} K_4 * \dfrac{1}{0.1\,S+1} \cdot \Delta h, \text{ for altitude hold} \\ 0, \text{ otherwise} \end{cases}$$

K_4 = altitude hold gain = 0.07 deg/ft

Δh = altitude hold signal, ft

Vertical Navigation Command —

$$\theta_{vnc} = \begin{cases} K_{10} * \Delta h_v, \text{ for vertical navigation} \\ 0, \text{ otherwise} \end{cases}$$

K_{10} = vertical navigation gain = 0.04 deg/ft

Δh_V = vertical navigation output from the navigation computer

Glideslope Command —

$$\theta_{gsc} = \begin{cases} K_6 * \Delta\theta_{gs}, \text{ for glideslope capture} \\ 0, \text{ otherwise} \end{cases}$$

K_6 = glideslope gain = 20.0 deg/deg before the middle marker is passed

= 7.5 deg/deg after the middle marker is passed

$\Delta\theta_{gs}$ = glideslope deviation input

The glideslope engage flag becomes true at zero crossing of

$$\left[\frac{1}{0.1\ s+1} \cdot \Delta\theta_{gs}\right]$$

Pitch Mode Command — The command is the sum of the previous control terms:

$$\theta_c = \theta_{pah} + \theta_{vtc} + \theta_{gac} + \theta_{hp} + \theta_{vac} + \theta_{ahc} + \theta_{vnc} + \theta_{gsc}$$

5.1.2.2.3 Roll Axis Terms --

Heading Hold Command --

$$\phi_{hhc} = \begin{cases} K_s * (\psi - \psi_{hs}), \text{ for heading hold} \\ 0, \text{ otherwise} \end{cases}$$

ψ = direction gyro heading shaped by an analog prefilter

ϕ_{hs} = heading hold synchronization

$$= \begin{cases} \psi_o, \text{ value of } \psi \text{ at engagement of heading hold, for heading hold} \\ \psi, \text{ otherwise} \end{cases}$$

K_s = heading gain = 1.0 deg/deg

Heading Select Command —

$$\phi_{hsc} = \begin{cases} K_s * (\psi - \psi_s), \text{ for heading select} \\ 0, \text{ otherwise} \end{cases}$$

ψ_s = heading select reference $= \dfrac{\Delta\psi_s}{S}$.

$\Delta\psi_s$ = heading slew command from mode controller

K_s = heading gain = 1.0 deg/deg

Course Datum Command —

$$\phi_{cdc} = \begin{cases} K_4 * \Delta\phi_{cd}, \text{ for navigation capture,} \\ K_4 * \left[1 - \underset{(\pm 30°)}{\text{limit}} \dfrac{1}{10\,S + 1}\right] \cdot \Delta\phi_{cd}, \\ \quad \text{for navigation track} \\ K_4 * K_{bc} * \Delta\phi_{cd}, \text{ for approach beam capture,} \\ K_4 * \left[1 - \underset{(\pm 30°)}{\text{limit}} \dfrac{1}{5\,S + 1}\right] \cdot (K_{bc} * \Delta\phi_{cd}), \\ \quad \text{for approach beam track,} \\ 0, \text{ otherwise} \end{cases}$$

K_4 = course datum gain = 1.5 deg/deg

$$K_{bc} = \begin{cases} +1, \text{ not backcourse} \\ -1, \text{ backcourse} \end{cases}$$

$\Delta\phi_{cd}$ = course datum signal from navigation computer

The backcourse flag is true if the magnitude of the course datum signal is greater than 90 degrees.

Lateral Beam Flags — The navigation and approach modes have submodes for arm, capture, capture with track armed, and track. These are switched on flags computed from the following quantities:

$$\Gamma = \frac{9}{S^2 + 3\,S + 9} \cdot \Delta\phi_{lb}$$

$$\Gamma_n = \frac{1}{S+1} \cdot \left[\frac{16\,S}{10\,S+1} + 1 \cdot\right]\Gamma$$

$$\Gamma_a = \frac{1}{S+1} \cdot \left[\frac{12.75\,S}{1.75\,S+1} + 1 \cdot\right]\Gamma$$

$\Delta\phi_{lb}$ = roll command from the navigation computer for lateral beam deviations

The flag, navigation capture, is true when Γ and Γ_n are of opposite signs. The flag, navigation track, is true when $|\Gamma| \leq 3$ dots and $|\phi| \leq 4$ deg. The flag, lateral beam capture, is true when Γ and Γ_a are of opposite signs. The flag, lateral beam track, is true when $|\Gamma| \leq 3$ dots and $|\phi| \leq 4$ deg.

Lateral Beam Commands for Approach —

$$\Gamma = \frac{9}{S^2 + 3\,S + 9} \cdot \Delta\phi_{lb}$$

$\Delta\phi_{lb}$ = roll command for lateral beam deviations from the navigation computer

$$\Gamma_1 = \begin{cases} 0.5\ \Gamma, & \text{(navigation track or approach beam track) and not localizer} \\ \Gamma, & \text{otherwise} \end{cases}$$

$$\Gamma_2 = \begin{cases} -0.5 * \Gamma_1, & \text{localizer backcourse and approach beam track} \\ -\Gamma_1, & \text{localizer backcourse and not approach beam track} \\ +\Gamma_1, & \text{otherwise} \end{cases}$$

$$\Gamma_{20} = \frac{30\,S}{10\,S+1} \cdot \Gamma_2, \text{ navigation track or approach beam track}$$

$$\Gamma_3 = \begin{cases} \Gamma_2 + \Gamma_{20}, & \text{navigation track or approach beam track} \\ \Gamma_2, & \text{otherwise} \end{cases}$$

$$\Gamma_4 = \begin{cases} \underset{(\pm 45^\circ)}{\text{limit}} \cdot \left[K_4 * \Gamma_3\right], & \text{navigation capture or approach beam capture} \\ \underset{(+10^\circ)}{\text{limit}} \cdot \left[K_4 * \Gamma_3\right], & \text{navigation track or approach beam track} \end{cases}$$

$$K_4 = \begin{cases} \text{4.0 DEG/DOT on NAV track and not RNAV} \\ \text{10.0 DEG/DOT on NAV capture and not RNAV} \\ \text{16.0 DEG/DOT on NAV track and RNAV} \\ \text{40.0 DEG/DOT on NAV capture and RNAV} \\ \text{25 DEG/DOT on LOC after middle marker} \end{cases}$$

$$\phi_{lbca} = \begin{cases} \Gamma_4, \text{ approach beam capture or approach beam track} \\ 0, \text{ otherwise} \end{cases}$$

Lateral Beam Command for Navigation —

$$\Gamma = \frac{9}{S^2 + 3S + 9} \cdot \Delta_{lb}$$

$\Delta\phi_{lb}$ = roll command for lateral beam deviations from navigation computer

$$\Gamma_o = \frac{120 S}{20 S + 1} \cdot \Gamma, \text{ for navigation track or approach beam track}$$

$$\Gamma_{so} = \begin{cases} \Gamma + \Gamma_o, \text{ navigation track or approach beam track} \\ \Gamma, \text{ otherwise} \end{cases}$$

$$\Gamma_s = \begin{cases} \Gamma_{so}, \text{ navigation capture or navigation track} \\ 0, \text{ otherwise} \end{cases}$$

$$\Gamma_s = \begin{cases} \underset{(\pm 10^\circ)}{\text{limit}} \cdot K_s * \Gamma_s, \text{ navigation track or lateral beam track} \\ \underset{(\pm 60^\circ)}{\text{limit}} \cdot K_s * \Gamma_s, \text{ otherwise} \end{cases}$$

$$K_s = \text{navigational gain} = \begin{cases} 4.0 \text{ on NAV track and not RNAV} \\ 8.0 \text{ on NAV track and RNAV} \\ 16.0 \text{ on NAV capture} \end{cases}$$

$$\phi_{lbcn} \begin{cases} \frac{1}{5S+1} \cdot \Gamma_s, \text{ navigation capture or navigation track} \\ \qquad \text{or} \\ 0, \text{ otherwise} \quad \text{approach beam capture or approach beam track} \end{cases}$$

Roll Mode Command — The command is the sum of the previous control terms:

$$\phi_c = \phi_{hhc} + \phi_{hsc} + \phi_{cdc} + \phi_{lbca} + \phi_{lbcn}$$

5.1.2.2.4 **Pitch Trim Servo** — The load on the pitch servo is sensed and used to adjust the trim tab servo. This is a continuous function done whenever the pitch servo is engaged. A delay of 6 seconds is used between the receipt of an out-of-trim signal and the starting of the trim tab motor. If the flap motor is sensed, this delay is reduced to 3

seconds. There is no delay in shutting off the trim tab motor when the force switch no longer senses out-of-trim.

5.1.3 Autopilot/Flight Director System Interfaces

The autopilot/Flight Director function involves a large number of devices:

- mode controller
- special switches
- dynamic sensors
- navigation, radio, and altitude devices
- mode annunciator
- flight director indicator
- pitch and pitch trim servos
- flap motor
- roll and yaw servos
- trim failure warnings

The connections to the computer are illustrated in Figure 26. The status of the flight control system is controlled by the switches on the mode controller box, four separate special switches, switches on the control panel for the navigation computer, and by several signals specifying the validity of sensor and radio information. Several capture and track signals also switch modes or submodes.

5.2 NAVIGATION/FLIGHT PLANNING FUNCTION

DAAS Navigation/Flight Planning Function enables the pilot to plan and store his flight plan, and monitor his status with respect to plan throughout the flight. In flight, a moving map display is presented on the DAAS EHSI which pictorially shows the aircraft position relative to the selected waypoint course and NAVAID. In the heading up mode the area directly ahead of the aircraft is mapped straight up from the aircraft symbol. A selectable "North Up" mode is available to allow more convenient comparison of the moving map display with a conventional map. A map slew feature is provided which allows one to view portions of the moving map which are otherwise out of view as a result of map scale.

The navigation function employs VORTAC-RNAV with automatic look-ahead to the next waypoint. The pilot is informed when the signal quality associated with the next waypoint is adequate. A Kalman filter is included to estimate the navigation situation

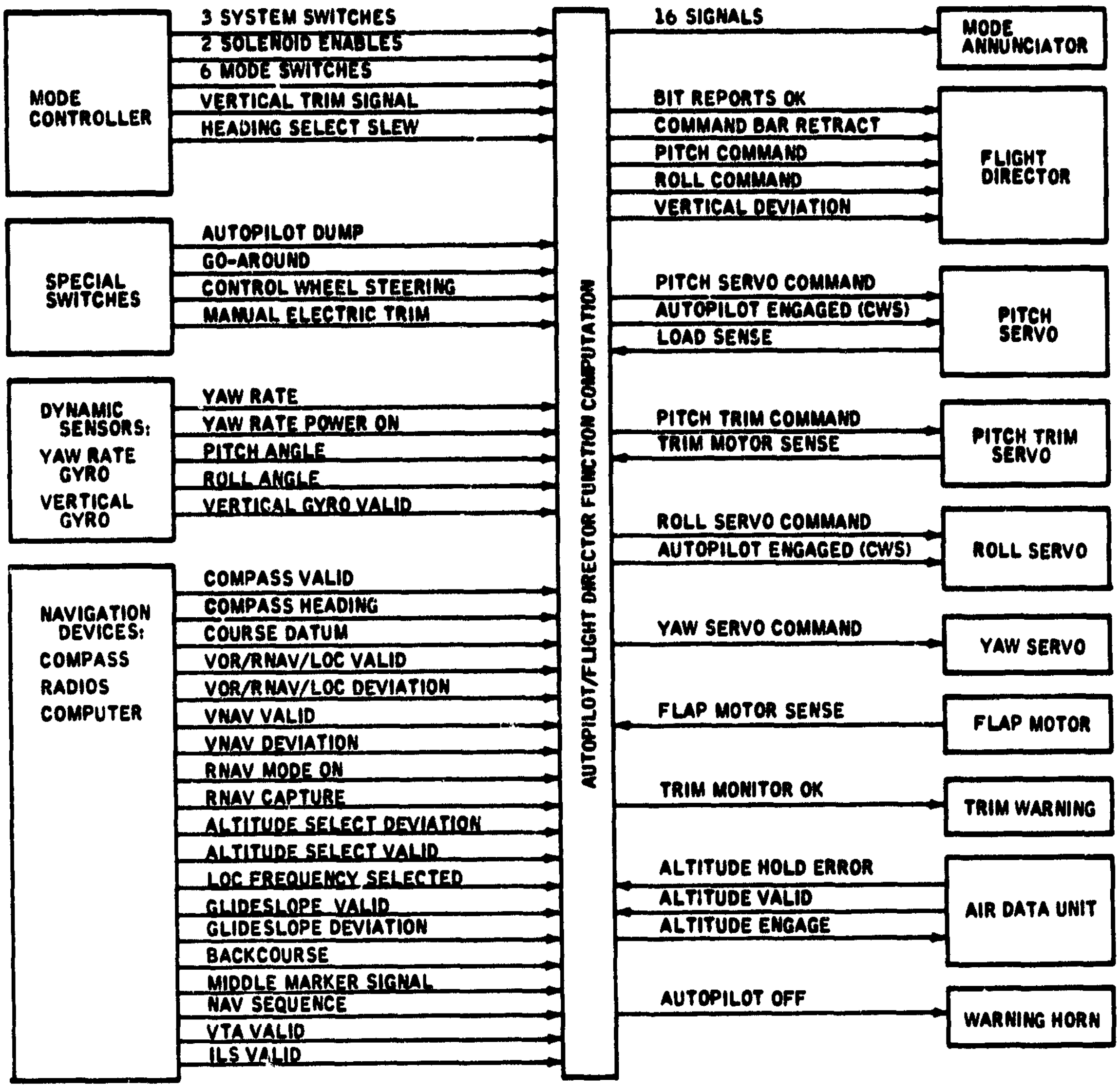


Figure 26. Autopilot/Flight Director Interfaces

by appropriately weighting dead reckoning position with radio-navigation signals. This filtered data is used for both the map determination and the generation of control steering signals to the autopilot and flight director.

5.2.1 Navigation/Flight Planning Controls and Displays

The navigation/flight planning function employs the IDCC for data input and readout, and the EHSI for map display. Following is a description of these various IDCC and EHSI controls and displays.

5.2.1.1 Navigation/Flight Planning IDCC Controls and Displays — IDCC Controls and Displays involved with Navigation/Flight Planning are shown in Figure 27. NAVAID data is stored on the NAVAID DATA page, and is tabulated for review on the NAVAID SMY page. Waypoint data is entered on the WP DATA page. Flight plan edit is possible using the MAP EDIT page. Flight status is available on the FLT STAT page. Flight plan data can be cleared on the INIT page. Use of these pages is described below.

NAVAID Data Page — NAVAID data is normally entered as a preflight operation.

If NAVAID data pages are selected, the NAVAID page number 1 will appear. It is necessary to access the desired NAVAID number page, if different from NAVAID 1, through the back/fwd control control or by direct data entry of the desired NAVAID number on the IDCC.

NAVAID data is stored in bubble memory periodically and is automatically reloaded into the appropriate RAM at power up. The NAVAID data can be cleared by use of the "DATA CLEAR" touchpoint on the INIT page.

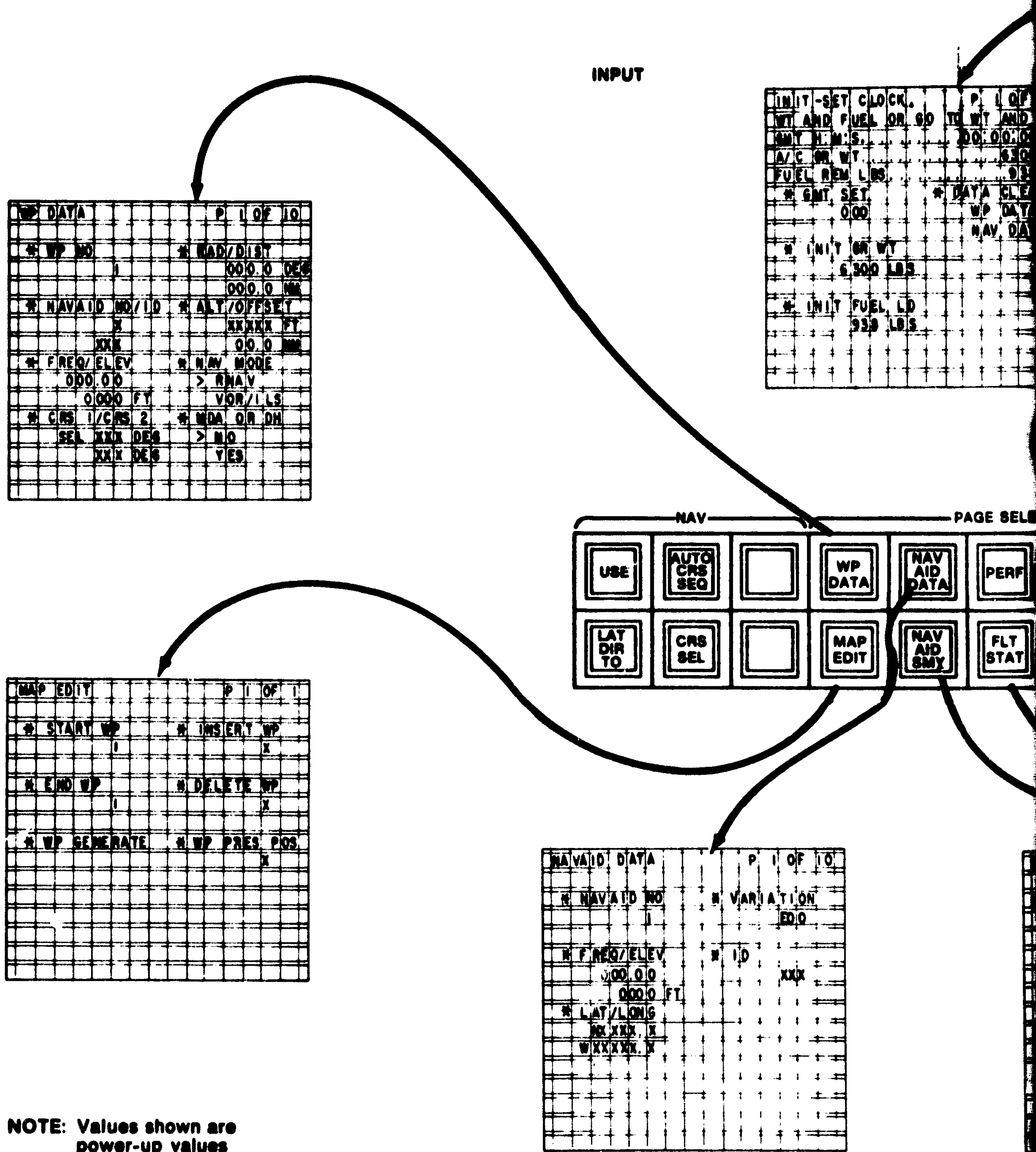
The N, W, and E associated with LAT/LONG and VARIATION need not be entered if they are applicable. They may be overridden with an alphabetical input proceeding the numerical input if appropriate.

If NAVAID data for a NAVAID referenced in a waypoint definition is changed, an IDCC data entry advisory "NAV USED IN WP DEF" is displayed.

In addition to format checks, entered NAVAID data is checked as follows:

1. Frequencies between 108 and 118 MHz, and multiple of 0.05 MHz.
2. NAVAID number between 0 and 10.
3. Latitude between 0 and 90 degrees, N or S or no prefix.
4. Longitude between 0 and 180 degrees, E or W or no prefix.
5. "Degree" entries between 0 and 59.9 minutes.
6. Magnetic variation prefix E or W, or no prefix and magnitude less than 100.
7. NAVAID ID has three characters.

If the format checks detect a violation, the data entry is not allowed to be entered, and an error message "DATA ENTRY ERROR" is displayed on the IDCC.



NOTE: Values shown are
power-up values

FOLDOUT FRAME

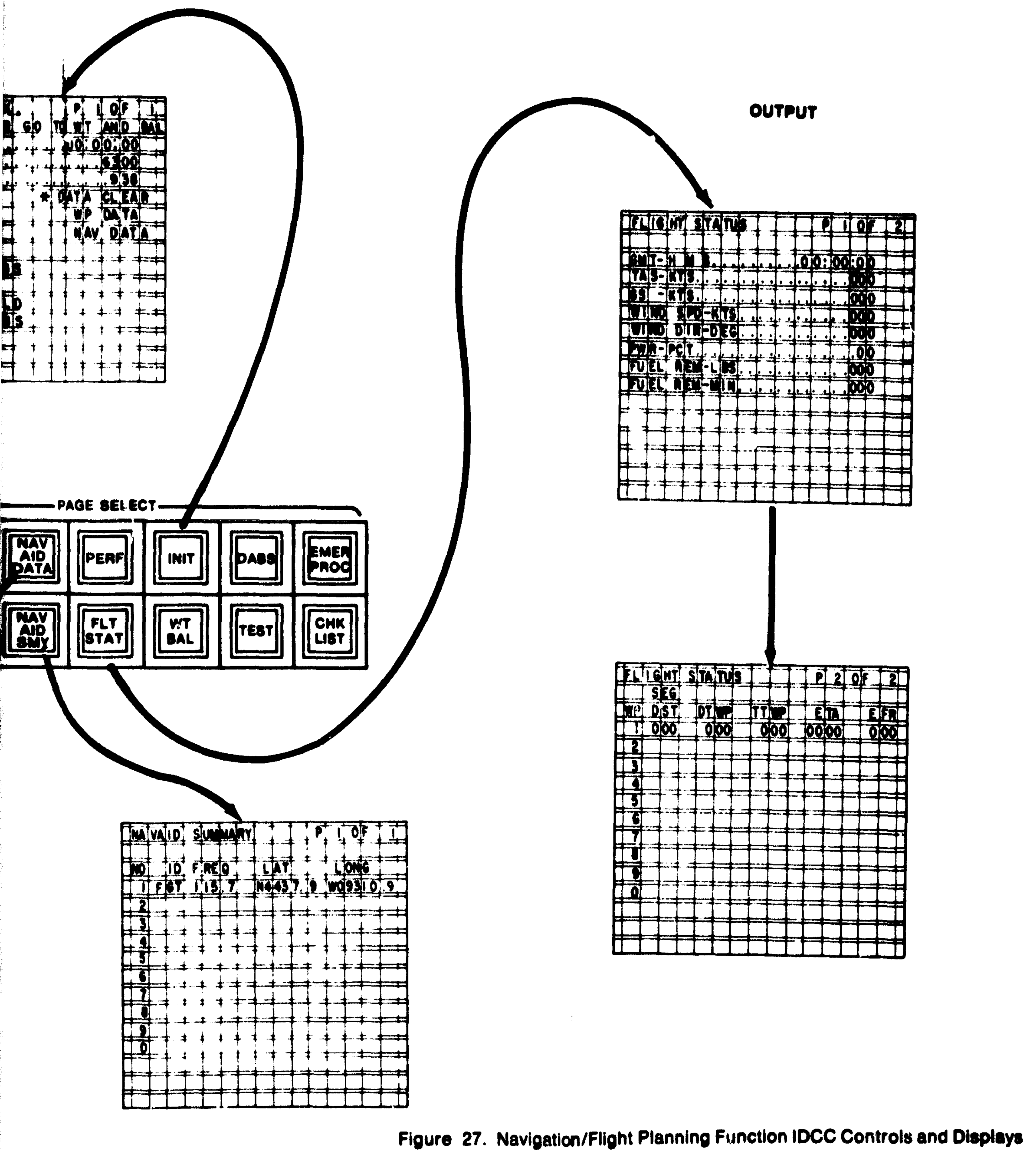


Figure 27. Navigation/Flight Planning Function IDCC Controls and Displays

FOLDOUT FRAME 2

NAVAID SMY Page — The NAVAID SMY page tabulates stored NAVAID data. The NAVAID SMY page is blank unless valid data has been entered.

Xs in the ID column designate a valid NAVAID facility for which identification code has not been entered.

Xs in latitude and longitude columns designate a valid NAVAID facility for which latitude and longitude has not been entered. Waypoints referenced to such NAVAIDS will not link.

WP DATA Page — The WP DATA page comes up with the active waypoint. Upon initialization waypoint 1 is the active waypoint. Another waypoint is made the active waypoint by displaying the desired waypoint on the WP DATA page and depressing the IDCC "USE" button. Changes to the active waypoint will be immediately reflected in the displayed map, and affect the guidance signals sent to the Autopilot/Flight Director function.

Waypoints are defined from this page. If a NAVAID number is entered for a NAVAID with stored data, the NAVAID ID, NAVAID frequency, and NAVAID elevation will be transferred to the WP DATA page.

Entry of a new NAVAID number will cause a new ID, frequency, and elevation to appear. Radial and distance are cleared to zero. New courses are computed based on this and other waypoint information. If new radial and distance are now entered, appropriate new courses are computed when entry arrows are cleared.

If frequency, ID, or station elevation are entered following the entry of a NAVAID number, the NAVAID number and related data (other than the parameter entered) will return to power up values.

If NAVAID number entry is attempted on the WP DATA page but no data is stored for this NAVAID, the NAVAID number, ID, frequency, and elevation will remain as they are. An error message "NO NAVAID DATA" is displayed.

Upon first selection of a particular WP DATA page, the NAV mode and MDA or DH toggle index shall indicate "RNAV" and "NO" for touchpoints 7 and 8, respectively.

PAGE 86 INTENTIONALLY BLANK

If the operator attempts to enter an invalid frequency, the old frequency is retained and "DATA ENTRY EPROR" is displayed as an error message.

If a localizer frequency is entered at touchpoint 3, the touchpoint 7 arrow will move to the VOR/ILS position. If the operator attempts to move the arrow index to the RNAV position with a localizer frequency selected, a "LOC FREQ SELECTED" error message is displayed.

With AUTO CRS SEQ off, passing over a waypoint does nothing to the course selected. If coupled, control continues to the same course outbound from the station unless the course selection is changed. If the course selection is changed, the Autopilot/Flight Director reverts to Heading Hold and Nav Arm. If the course selection was made prior to or during the time the Nav Capture flag becomes true, the new course will be captured automatically.

Waypoint data is stored in bubble memory periodically and is automatically reloaded into the appropriate RAM at power up. The waypoint data can be cleared by means of the DATA CLEAR touchpoint on the INIT page.

All waypoints that are inactive will show the SEL opposite course 1. Only the active waypoint SEL is toggled by the course select pushbutton.

A waypoint is linked if:

- The waypoint and the previous waypoint are located with respect to NAVAIDs for which latitude and longitude have been entered.
- Course 1 has not been manually entered for this waypoint and course 2 was not manually entered for the prior waypoint.

If data is changed for the NAVAID number to which the waypoint is referenced, the NAVAID number on the waypoint data page will go back to an X, and a data entry advisory NAV USED IN WP DEF is displayed.

If a previously linked waypoint is unlinked from either of its neighbors by the manual entry of course 2 on the previous waypoint, the courses on the waypoint data page will remain unchanged.

All courses associated with the active waypoint will be displayed on the EHSI unless they are XXXs.

If latitude and longitude are not defined on the NAVAID DATA page and this NAVAID is used to define a waypoint, the data will properly transfer to the WP DATA page, but linking of the waypoint to another is not allowed.

ALT/OFFSET defines the waypoint altitude and the vertical waypoint position offset. OFFSET is positive for a vertical waypoint before an RNAV waypoint. The entered altitude is the reference for VNAV, altitude select, the altitude alert function, and is the MDA or DH if so designated by the lower right touchpoint.

FLT STAT Page — Data on these pages represents current conditions as measured or computed.

FUEL REM (TIME) is based on the fuel remaining (lbs) divided by the current fuel flow (lbs per minute).

Data is presented for the active waypoint and all waypoints linked to the active waypoint.

Distances are computed based on WP DATA position entries.
Times are computed based on known distances and computed present ground speed.

Fuel remaining is estimated based on present fuel load, fuel flow, and estimated time to waypoint.

If off course, the distance to the next waypoint is the straight line distance to the active WP if course 1 is selected, and the leg distance minus the distance back to the active waypoint if course 2 is selected.

MAP EDIT Page — This page is used when it is desired to alter a previous flight plan or to generate waypoints along a prescribed course.

When "WP INSERT" is activated:

- The previous waypoint as indicated by the number entered under insert WP and all subsequent waypoints are renumbered.
- WP DATA page is then selected automatically for the new waypoint number to allow insertion of new waypoint data.

When WP DELETE is activated:

- The waypoint, as indicated by the number entered under delete WP, is deleted and all subsequent waypoints are renumbered.
- WP DATA page is then selected automatically for the waypoint number that was deleted.

When "WP GENERATE" is activated:

- Waypoints will be generated to sequentially fill the set defined by the "START WP" and "END WP". Both start and end waypoints must be referenced to NAVAIDs with entered latitude and longitude data.
- The waypoints generated will be equally spaced on a course line drawn from the "START WP" to the "END WP".
- Each generated waypoint will be referenced to the closest NAVAID shown on the "NAVAID SUMMARY" page.

When WP PRES POS is touched, an entry arrow will appear opposite the "x" beneath the touchpoint. Upon entry of a number to designate the desired waypoint identification, the data corresponding to the aircrafts present position will be copied onto the designated waypoint data page which will be displayed automatically. All data on the designated waypoint data page will be taken the same as that of the active waypoint except RAD, DIST, and CRS, which are computed for present position.

The designation of the present position WP number will be inhibited and an error message "INVALID RADIO" will be displayed if the active waypoint does not allow proper NAV radio reception.

Faulty entry diagnostic messages associated with map edit are as follows:

Entry	Fault	IDCC Message
START WP	Start waypoint not defined	WP NOT LOCATED
END WP	Designated end waypoint number less than start waypoint number	WP LESS THAN START
END WP	End way point not defined	WP NOT LOCATED
INSERT WP	Inserted waypoint is eleventh or higher waypoint	WP STORAGE LIMIT

DELETE WP	Deleting active waypoint	ACTIVE WP
WP PRESENT POSITION	NAVAID not received	INVALID RADIO

INIT Page — Navigation/flight planning stored data can be cleared using touchpoints on the INIT page. Stored NAVAID and waypoint data can be cleared separately.

Touching the DATA CLEAR touchpoint causes an entry arrow to appear. Subsequent touchpoint touches will toggle the arrow between the two types of data. To clear either type of data from the system, the clear button is depressed with a clear scratch pad. To cause the arrow to advance without clearing the data from the system, the ENTER button is depressed with a clear scratchpad.

5.2.1.2 Navigation/Flight Planning IDCC Controls — Navigation/flight planning function controls located on the IDCC (see Figure 28) are as follows:

USE — USE will activate the waypoint displayed on the IDCC. If the WP DATA page is not on the IDCC, nothing will happen when the USE button is pushed. The USE button is only used for selecting active waypoints. If the displayed waypoint data is incomplete, an IDCC data entry "WP NOT DEFINED" is displayed.

CRS SEL — CRS SEL will toggle the WP DATA page CRS 1/CRS 2 SEL mnemonic between CRS 1 and CRS 2 for the active waypoint. The EHSI display will change to show the new course and course deviation relative to the newly selected course. If AUTO CRS SEQ has been selected, the CRS SEL button will change the selected course and cause the system to revert to manual sequence (AUTO CRS SEQ OFF). If the selected course is not defined, the message "COURSE NOT DEFINED" is displayed.

AUTO CRS SEQ — The AUTO CRS SEQ (or Auto Course Sequence) button is pushed to toggle between the ON and OFF states for auto course sequence. AUTO CRS SEQ ON will cause DAAS to automatically transition from the "in" course (course 1) to the "out" course (course 2). The autopilot/flight director control laws are such that a smooth asymptotic capture is executed for course intersection angles less than 90°. The "Auto Course Sequence On" state is indicated by lighting the button. Activation of auto course sequence (or activation of USE with auto-course-sequence-on) with no course 2 defined for the active WP will result in an IDCC data entry advisory "CRS 2 NOT DEFINED."

C-2

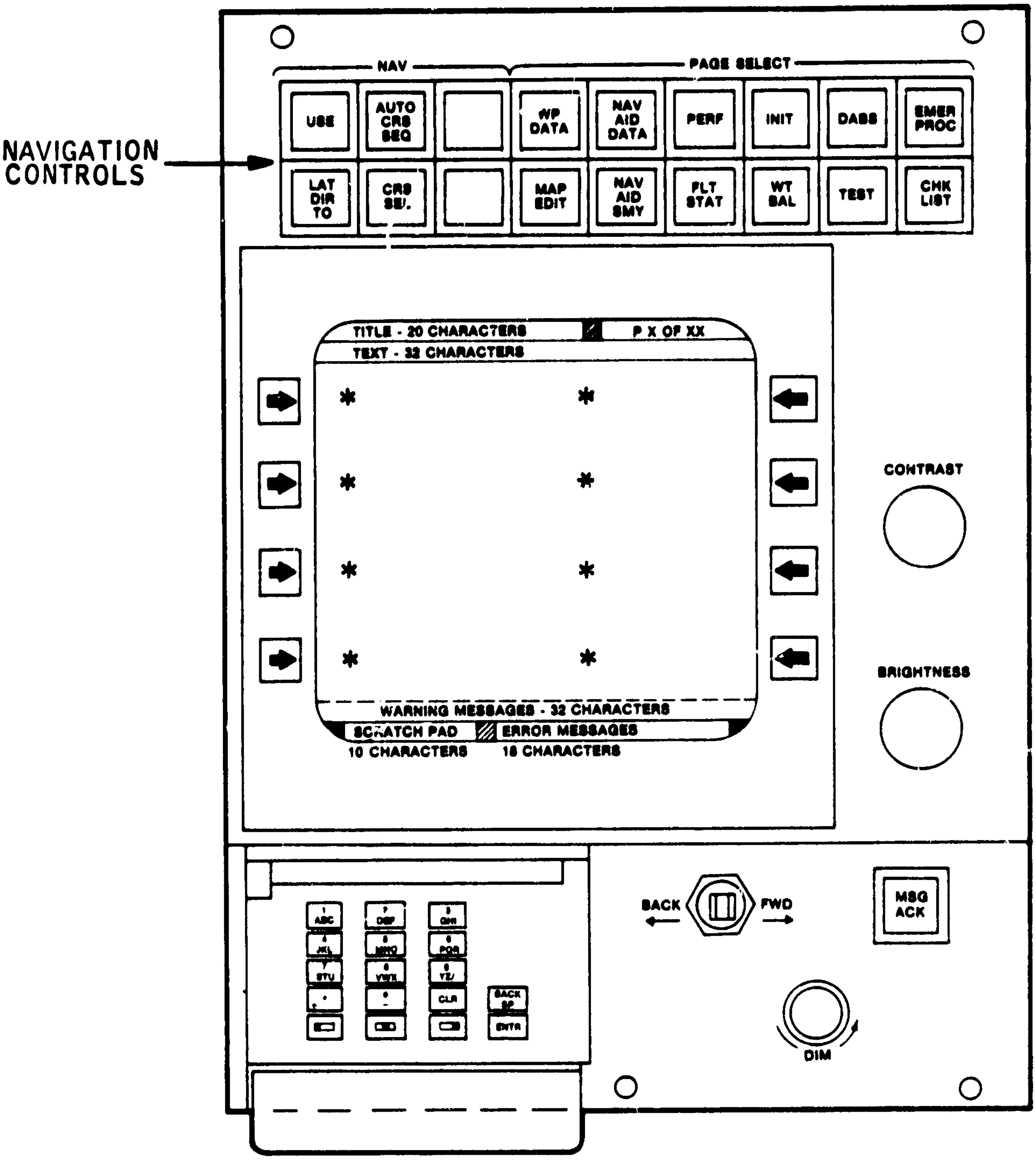


Figure 28. Navigation/Flight Planning IDCC Controls

LAT DIR TO — LAT DIR TO will set course "1" to the course which would direct the aircraft to the active waypoint and makes course "1" the selected course.

Activation of LAT DIR TO when the active waypoint is not an RNAV waypoint results in the IDCC data entry advisory "NOT RNAV WP." LAT DIR TO with an incomplete active waypoint results in the IDCC data entry advisory "WP NOT DEFINED."

5.2.1.2 Navigation/Flight Planning EHSI Controls and Displays —EHSI controls and displays associated with Navigation/Flight Planning are shown in Figure 29.

EHSI Navigation/Flight Planning Function Controls, shown in Figure 29, include:

HDG/NOR — HDG/NOR changes the map from heading up (inside-out display) to a North-up orientation and vice versa. Lighted annunciation.

MAP/CRSR — MAP/CRSR changes the slew control to affect either the cursor or the map. If the cursor is the selected state, a cursor appears superimposed on the active waypoint. Cursor mode operation is defined below. Lighted annunciation.

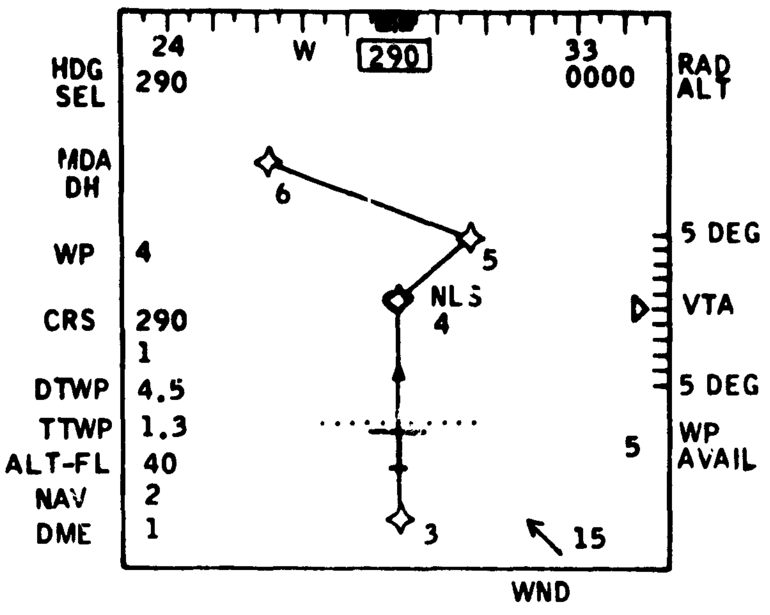
MAP RETURN — MAP RETURN returns the map to the normal position (not slewed/map mode).

WP BRG — WP BRG causes the active waypoint bearing needle to be deleted from the display if present or to be displayed if not present. Lighted annunciation.

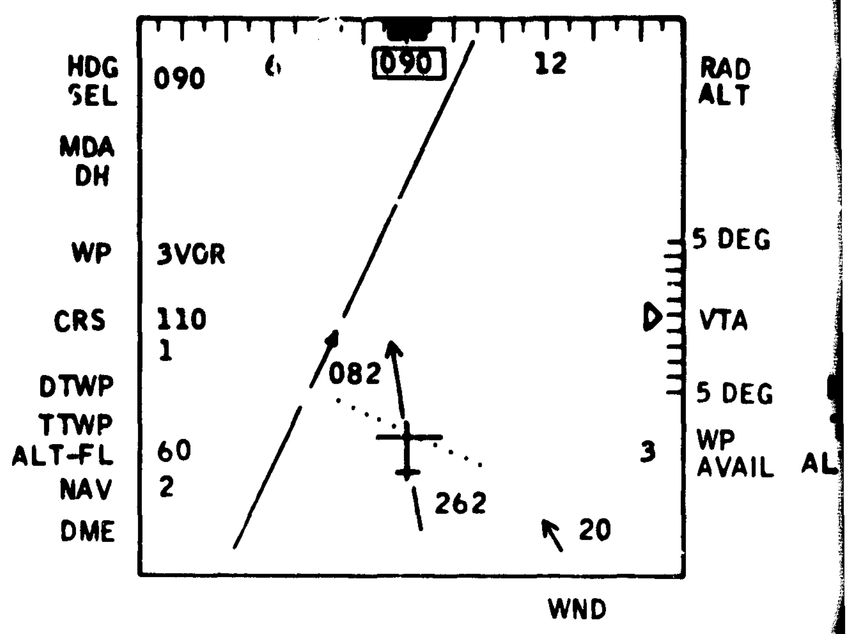
MAP REVU — MAP REVU causes the map to appear when no radio signals are available. The active waypoint is located at the airplane location. The purpose is to allow preflight review of the planned flight using the map slew feature. The aircraft symbol is not shown in MAP REVU mode.

MAP SCALE —

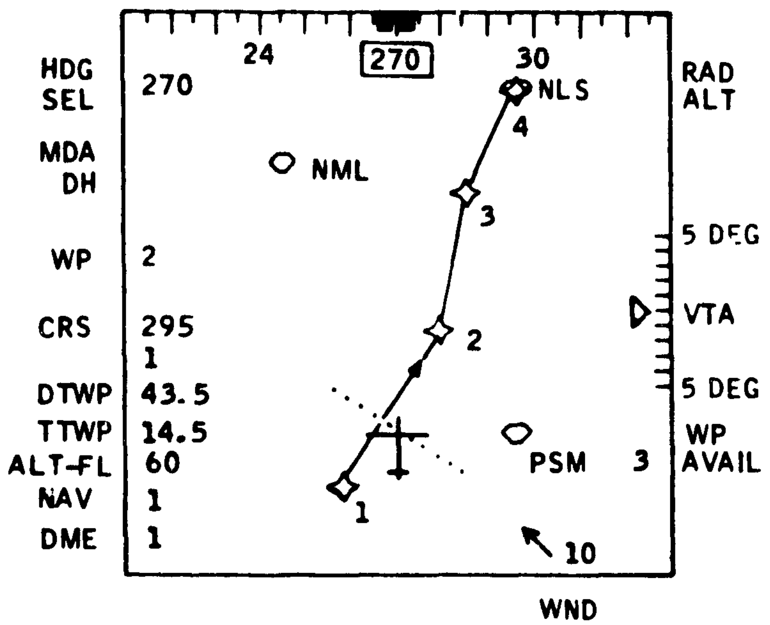
- 2 NM/inch, Map scale select. Lighted annunciation.
- 8 NM/inch, Map scale select. Lighted annunciation.
- 40 NM/inch, Map scale select. Lighted annunciation.



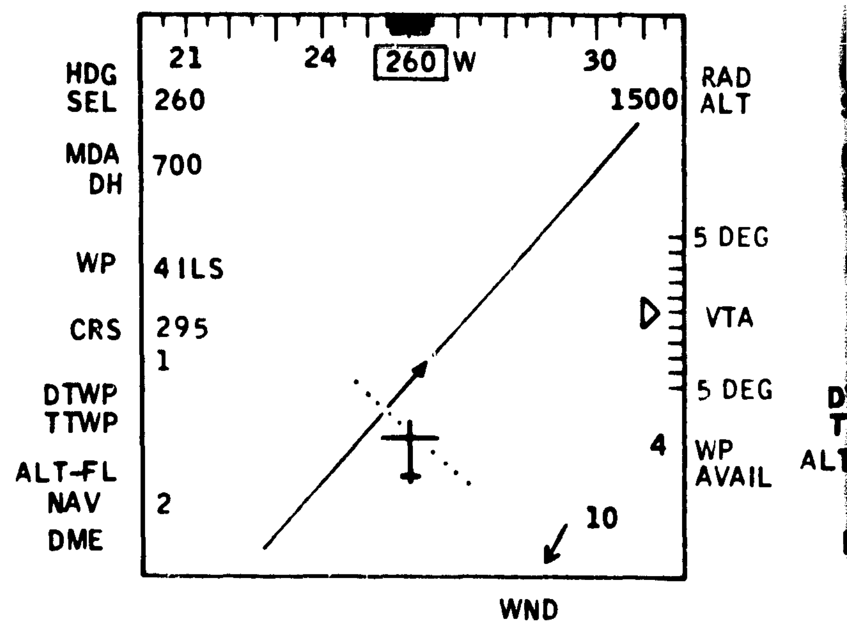
RNAV MODE, 8NM/INCH SCALE



VOR MODE, 2 DEG/DOT SCALE

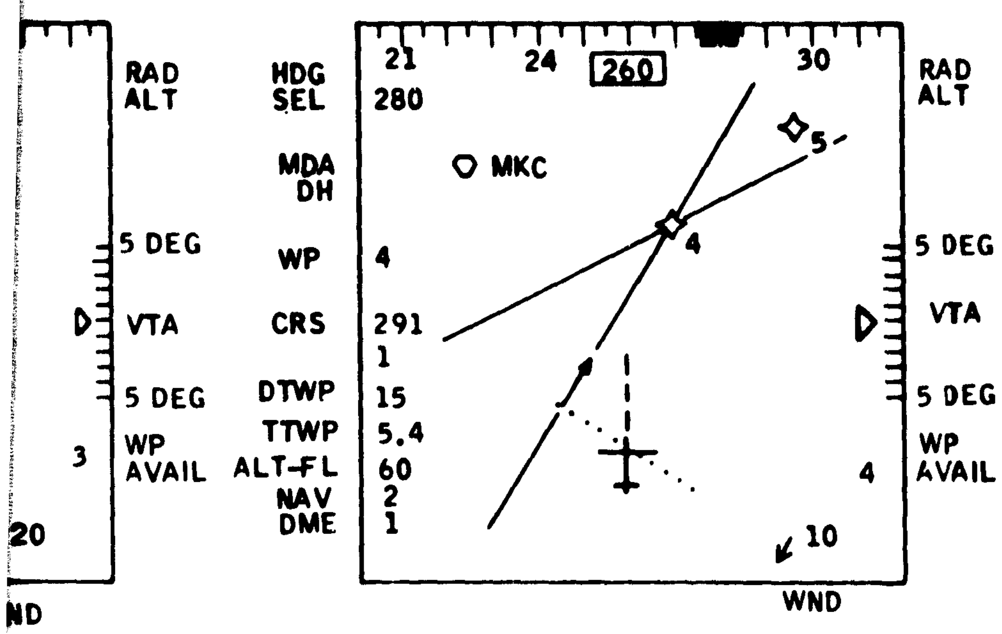


RNAV MODE, 40 NM/INCH SCALE



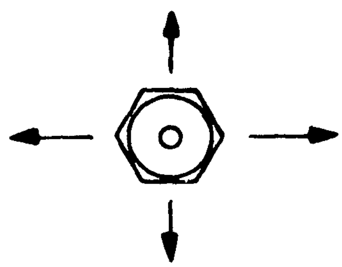
ILS MODE, 0.5 DEG/DOT SCALE

FOLDOUT FRAME

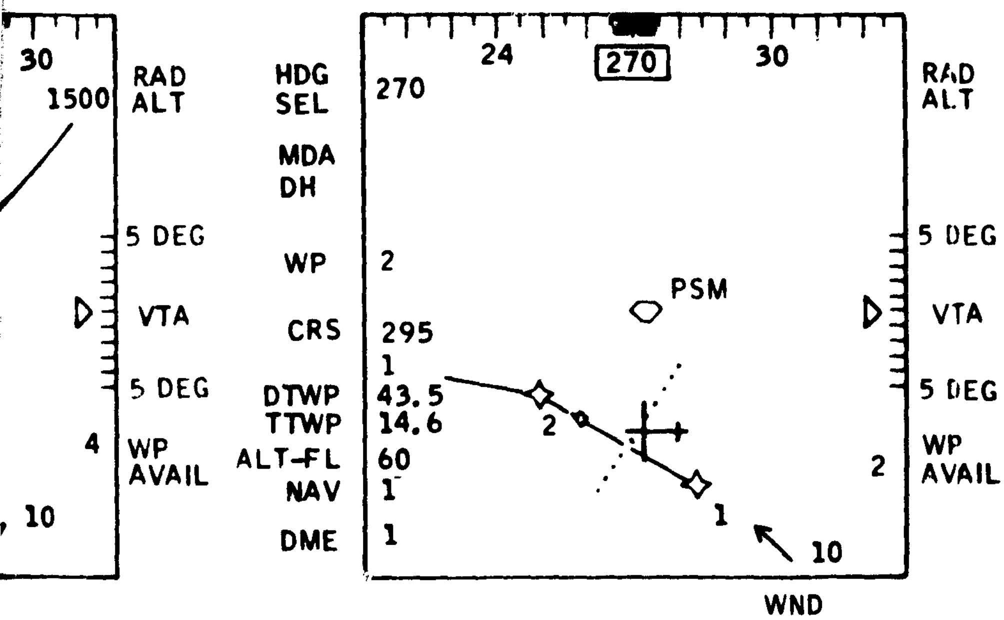


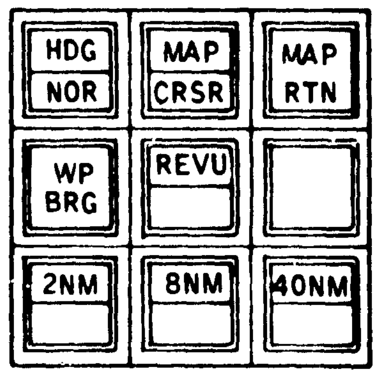
ALE

RNAV MODE, UNLINKED WAYPOINT, 8NM/INCH SCALE



SLEW CONTROL





EHSI CONTROL

SCALE

RNAV MODE, NORTH UP ORIENTATION, 40NM/INCH SCALE

Figure 29. NAV/Flight Planning EHSI Display Formats

FOLDOUT FRAME 2

94

The 2-NM/inch scale is suitable for tight control situations such as approach, and the 8-NM/inch is suitable for enroute. The 40-NM/inch allows for display of approximately 100 NM forward of the EHSI aircraft symbol. This distance is sufficient for several enroute waypoints.

Lateral deviation is presented by five dots on either side of the aircraft symbol. The dots are 0.125 inch apart. The 2 NM/inch map scale results in 0.25 NM/DOT, 8 NM/inch results in 1.0 NM/DOT, and 40 NM/inch results in 5 NM/DOT scaling.

The VOR scale is 2 degrees/dot and the ILS scale is 0.5 degree/dot. Deviation is limited to 6 dots.

Examples of EHSI map displays set up using these controls are illustrated in Figure 29. Included are:

- RNAV MODE, 2 NM/inch and 8 NM/inch — These scales are best suited for operations in a terminal control area (TCA) or in performing an RNAV approach. In this illustration the aircraft is approaching WP4 NLS, a VORTAC which is providing the signals for defining WP5 and 6. The flight plan is for an RNAV approach to Nelson Airport, Kansas. WP5 is the initial approach fix (AF) and WP6 is the missed approach point (MAP). The MDA is 1600 feet MSL. The MDA will be displayed as soon as WP6 becomes active.

- RNAV MODE, 40 NM/inch — This scale is most suitable for viewing the flight plan. The illustration shows the aircraft enroute to Nelson VORTAC. At this moment the aircraft is 6 miles to the right of the selected course.

- VOR MODE, 2.0 DEG/DOT — This mode, since no distance information is available, cannot show a map. The aircraft is far to the right of the selected course.

- ILS MODE, 0.5 DEG/DOT — This mode does not show a map because no distance information is available. The aircraft is 1.5 degrees to the right of the ILS localizer.

- RNAV MODE, UNLINKED WAYPOINT, 8 NM/inch — This figure shows an unlinked RNAV display. Waypoint 4 is the active waypoint. The two courses entered for the waypoint are shown as course lines extending through the waypoint. Course 1 (291°) has been selected as indicated by the CRS entries at the left of the display, and the course direction arrow.

Waypoint 5 is also shown on the map. If the active WP NAVAID is located (i.e., has latitude and longitude defined), then all other located waypoints and NAVAIDs will be drawn. In this case, waypoints 4 and 5 must both be referenced to located NAVAIDs such as MKC as shown on the map.

- RNAV MODE, NORTH UP ORIENTATION — This figure shows the same RNAV, 40 NM/inch situation as it would appear with a north up orientation. The airplane occupies the same location as for the heading up orientation and the map moves with respect to the airplane as the flight progresses. The airplane will rotate as the heading is changed. If desired, the map slew feature may be used to reposition the airplane (and map) to a more desirable position.

The EHSI will only show NAVAID identifiers entered by the pilot. Where an identifier is entered, the system will correlate the identifier entered with the Morse code radio identifier. A warning message is displayed after two minutes in the IDCC warning message area and the amber caution light is lighted if no correlation has been established.

Cursor Control — The pilot calls up the WP DATA page on the IDCC and selects the waypoint number he wants to assign to the cursor waypoint. If he wants to insert, he calls up the MAP EDIT page.

The pilot then pushes the CURSOR button on the EHSI Control Panel and the following things happen:

- The cursor appears on the EHSI superimposed on the active waypoint.
- The cursor can be moved using the slew control. After the cursor is moved to the desired location, pushing the ENTER button will cause the active waypoint data modified for the cursor radial and distance information to be copied on the displayed waypoint data page. New courses are computed and appear on WP DATA page if the waypoints are linked. The waypoint can then be activated by touching USE.

If the cursor designated waypoint is the active waypoint, the same things happen as defined above. The new cursor designated WP becomes the active WP as soon as "ENTER" is pushed.

The cursor moved or inserted waypoints must be referenced to the active waypoint NAVAID.

The activation of touchpoint or depressing of any IDCC key other than MSG ACK, CLEAR, or DABS, will cause the cursor mode to be disengaged. The entering of both radial and distance of the cursor designated waypoint (by pushing the "ENTER" button) will cause the cursor to disappear.

Map Slew Control — Map slew is accomplished using the slew controller. Slew range limits are 33 degrees of latitude and longitude, or 999 miles. Slew rates are ±0.2-inch/second, or ±1.0-inch/second depending on slew controller displacement. The map can be recentered using the MAP RTN control.

5.2.2 Navigation/Flight Planning Algorithms

Kalman Filter Mechanization — The DAAS navigation/flight planning function employs a Kalman filter to determine aircraft position. The filter blends VOR/DME with dead-reckoning true airspeed and heading information.

The major advantage to this formulation is that it provides a method of estimating mean winds and can provide position estimates better than either VOR/DME or dead-reckoning alone. This improvement depends on how the error sources are modeled, and in particular their frequency content.

Aircraft-to-station geometry enters the measurement equation. This is true whether one works in an R-θ coordinate frame, or an X-Y coordinate frame. In the DAAS design a steady-state solution was obtained for a variety of aircraft-station geometries. The Kalman filter gains were then plotted as functions of R and θ. Plots of these gains were used to schedule the gains with range and bearing to the station. This approach reduced the on-board computations required without sacrificing performance.

The resulting filter is depicted in Figure 30. Filter gains are tabulated in Table 2.

The blending function of this Kalman filter is apparent if one examines the continuous version of the filter at 0° bearing. The X and Y estimates decouple and each has the form of Figure 31.

In Figure 31, $\widehat{W}_x$ is the wind state and $\widehat{X}_x$ the position estimate. The transfer function for $\widehat{X}_x$ is:

$$\widehat{X}_x = \left[\frac{S+\epsilon}{S^2 + (\epsilon + K_1) S + K_2 + \epsilon K_1} \right] \widehat{U}_x + \left[\frac{K_1 (S+\epsilon) + K_2}{S^2 + (\epsilon + K_1) S + K_2 + \epsilon K_1} \right] \widehat{Y}_x$$

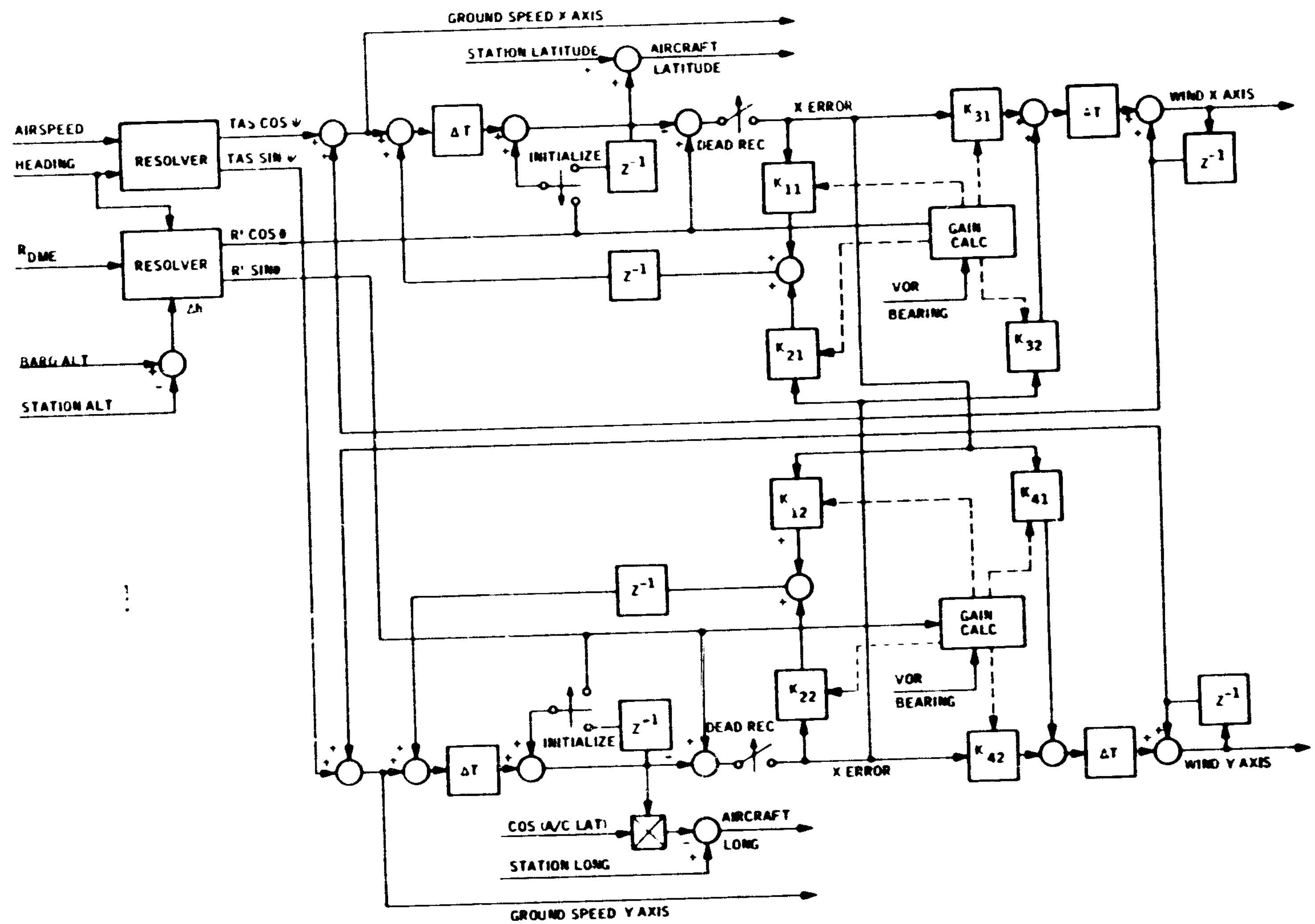


Figure 30. Navigation Kalman Filter Mechanization

Table 2. Navigation Kalman Filter Gains

<u>Natural Frequency (sec) of X Filter to X Error</u>

$$\omega_{xx} = .2 + \left[\left(\frac{.8}{R + 5}\right) - .17\right] \sin^2\theta$$

<u>Natural Frequency (sec) of Y Filter to Y Error</u>

$$\omega_{yy} = .2 + \left[\left(\frac{.8}{R + 5}\right) - .17\right] \cos^2\theta$$

Where: R = Measured range corrected for altitude in NMI

θ = Measured bearing to station in Deg.

X = Distance in NMI WRT NORTH

Y = Distance in NMI WRT EAST

ζ = Damping of 2nd order filter = .7

<u>Filter Gains</u>

$k_{11} = 2\zeta\omega_{xx} = 1.4\ \omega_{xx}$

$k_{22} = 2\zeta\omega_{yy} = 1.4\ \omega_{yy}$

$k_{31} = \omega_{xx}^2$

$k_{42} = \omega_{yy}^2$

$k_{21} = 2\zeta\ (.07\sin 2\theta).1\sin 2\theta$

$k_{21} = k_{21} = .1\sin 2\theta$

$k_{32} = (.07\sin 2\theta)^2 \sin 2\theta$
$= |(.07\sin 2\theta)| \times (.07\sin 2\theta)$

$k_{41} = k_{32} = |(.07\sin 2\theta)| \times (.07\sin 2\theta)$

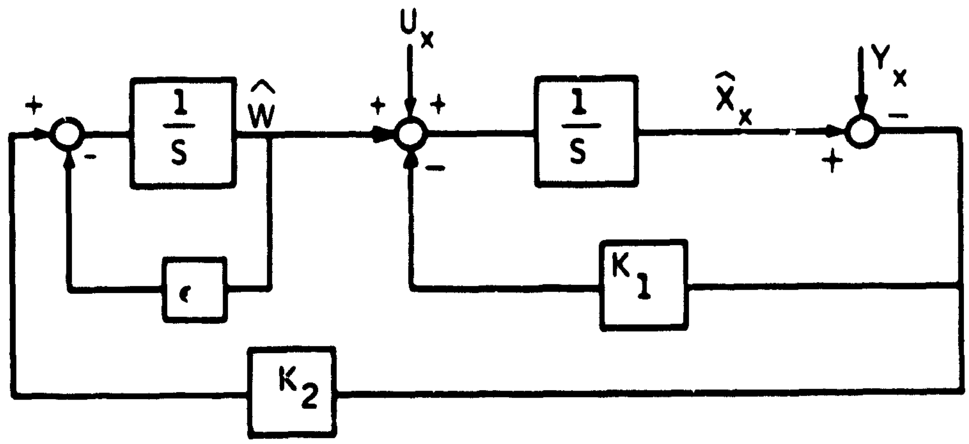


Figure 31. Kalman Filter, Simplified Form

$\epsilon \approx 0$ if the wind is assumed constant.

Thus X is high-passed U (dead-reckoning via air data) and low-passed Y (position from VOR/DME). Typical values for the gains are:

	R = 5 NM	R = 50 NM
X Axis	K_1 0.28	K_1 = 0.28
	K_2 0.031	K_2 = 0.031
Y Axis	K_1 0.22	K_1 = 0.07
	K_2 0.02	K_2 = 0.0023

Thus for the X axis the second order filter has ω = 0.18 and ζ = 0.77 in the denominator. Note its dynamics don't change with range since ΔX errors are due to ΔR (DME errors). For the Y axis a similar filter is obtained. However, as R increases the filter bandwidth decreases. This is expected since ΔY errors are $R\Delta\theta$. Thus as the Y measurement becomes less accurate with range the filter reduces the bandwidth.

Finally, the scheduled gains developed account for all coupling and geometry and are directly computed.

Map Computations — The EHSI map is drawn to look like the aircraft navigation maps; i.e., Lambert conical projection maps. On such a map great circles are drawn approximately as straight lines. This means that the lines of longitude will be straight, but not parallel and that the lines of latitude will be curved lines.

The mathematics of the conical projection are too complex to be used when drawing the DAAS EHSI map. Instead, a plane projection is used with the projected distance between the map basis (the airplane or the active waypoint) and the point to be mapped being the true great circle distance. See Figure 32. This projection is very close to that of the aircraft navigation maps, and for distances less than 200 miles the relative error in distance is less than .05%.

The mathematics of great circle distance and course are also too complex to be used when drawing the DAAS EHSI map, but with the help of some approximations, the circle formulas can be reduced to manageable expressions for computing the coordinates on the EHSI map. The approximate map coordinate computation equations are:

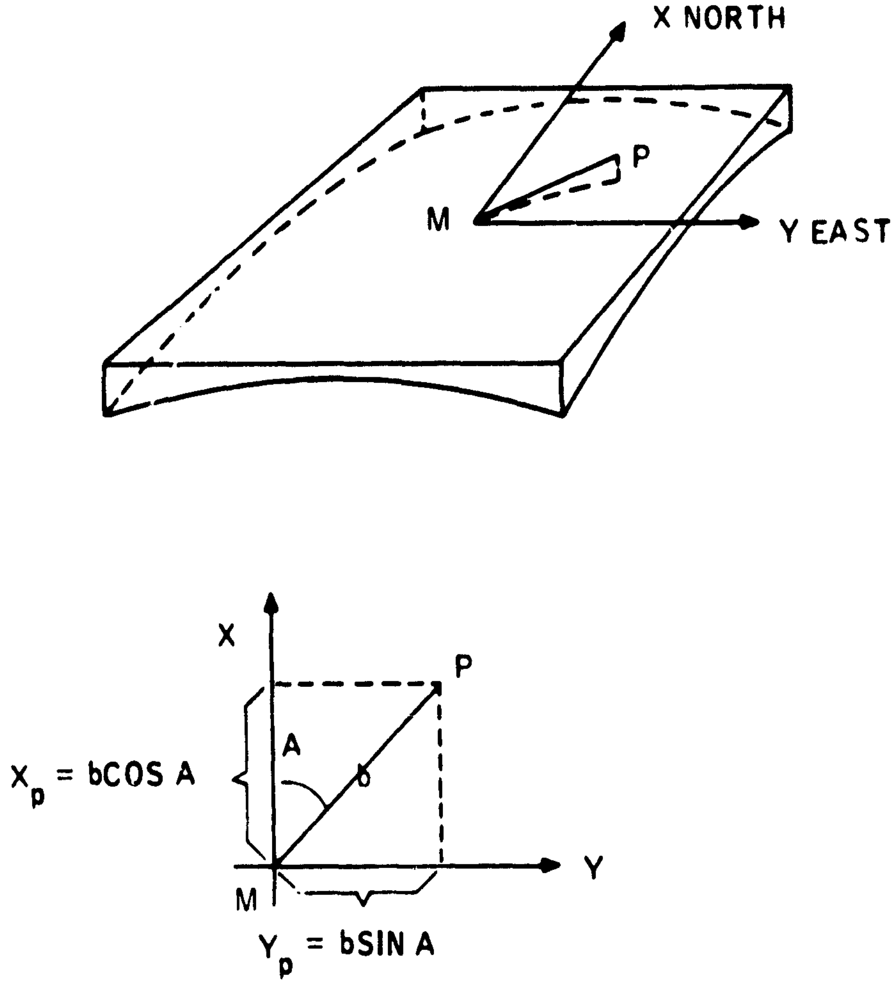
$$X_p = (L_p - L_m)$$
$$Y_p = (\lambda_m - \lambda_p) \cdot \cos L_p$$

Where L_p, λ_p are the lat-long of an arbitrary point P and L_m, λ_m are the lat-long of the map basis (a/c or active waypoint), and X_p, Y_p are the rectangular coordinates of the point P on the EHSI map. The result of this approximation on the map is like making the curved lines of latitude into straight lines. See Figure 32. In the 40-nm/inch scale the display is 180×180 nm and the worst case relative error in distance across the EHSI map is about 1% and the relative error in radial is about 1.5%.

Map Slew — The map slew function gives the pilot the possibility to move the map relative to the display screen, or as it also could be understood, move the display screen window over the map. Independent of the map slew, the map is rotated and scaled relative to the map basis which, except in map review, is the aircraft. After the map computations, the slews are added as display offsets.

The advantage of this mechanization is that the aircraft does not move off the map when it is turning, which could very well happen if the center of the display was used as the point around which the map rotated.

There are however, some disadvantages. If we use the map slew to slew off to a relative distant point, we cannot use the map scales to blow up that area, since the expansion is done around the map basis (i.e., the aircraft). The map projection described earlier also produces the effect that if we slew off some distance, then the compass directions will change relative to the display.



b = GREAT CIRCLE DISTANCE BETWEEN M (MAP BASIS) AND P (POINT)

A = INITIAL COURSE FROM M TO P

X_p = bCOS A = PLANE PROJECTION DISTANCE IN X DIRECTION BETWEEN M AND P

Y_p = bSIN A = PLANE PROJECTION DISTANCE IN Y DIRECTION BETWEEN M AND P

Figure 32. Plane Projection

However, the disadvantages above can be avoided by using map review and north up modes, and as long as the slew offsets are short, the slew will be more useful for positioning the aircraft symbol and related information on the display.

The mapping of an arbitrary point P on the EHSI display is computed as follows. See Figure 33.

1. Projected distances relative to the aircraft:

$$X_p = (L_p - L_{AC})$$
$$Y_p = (\lambda_{AC} - \lambda_p) \cdot \cos L_p$$

2. Rotation with respect to aircraft heading if in heading up mode:

$$X_p^r = X_p \cos \Psi + Y_p \sin \Psi$$
$$Y_p^r = - X_p \sin \Psi + Y_p \cos \Psi$$

3. Addition of slew offsets and conversion to display coordinates:

$$Ydisp = -(X_p^r - Xslew)$$

$$Xdisp = (Y_p^r - Yslew)$$

Where L_p, λ_p is the lat-long of an arbitrary point P, L_{AC}, λ_{AC} is the lat-long of the aircraft. Ψ is the aircraft heading and Xslew, Yslew are the map slew offsets.

The map slew offsets come from integration of constants:

$$Xslew = \int_0^t g_{xdt}$$

$$Yslew = \int_0^t g_{ydt}$$

where g_x, g_y = 0, ±0.2, ±1 inch/sec depending on the position of the slew switch. g_x, g_y are forced to zero when not in map mode and the integrations are reset to zero if MAP RTN button is depressed or if change of map basis is done. Change of map basis is done by entering map review mode or changing active waypoint in map review mode.

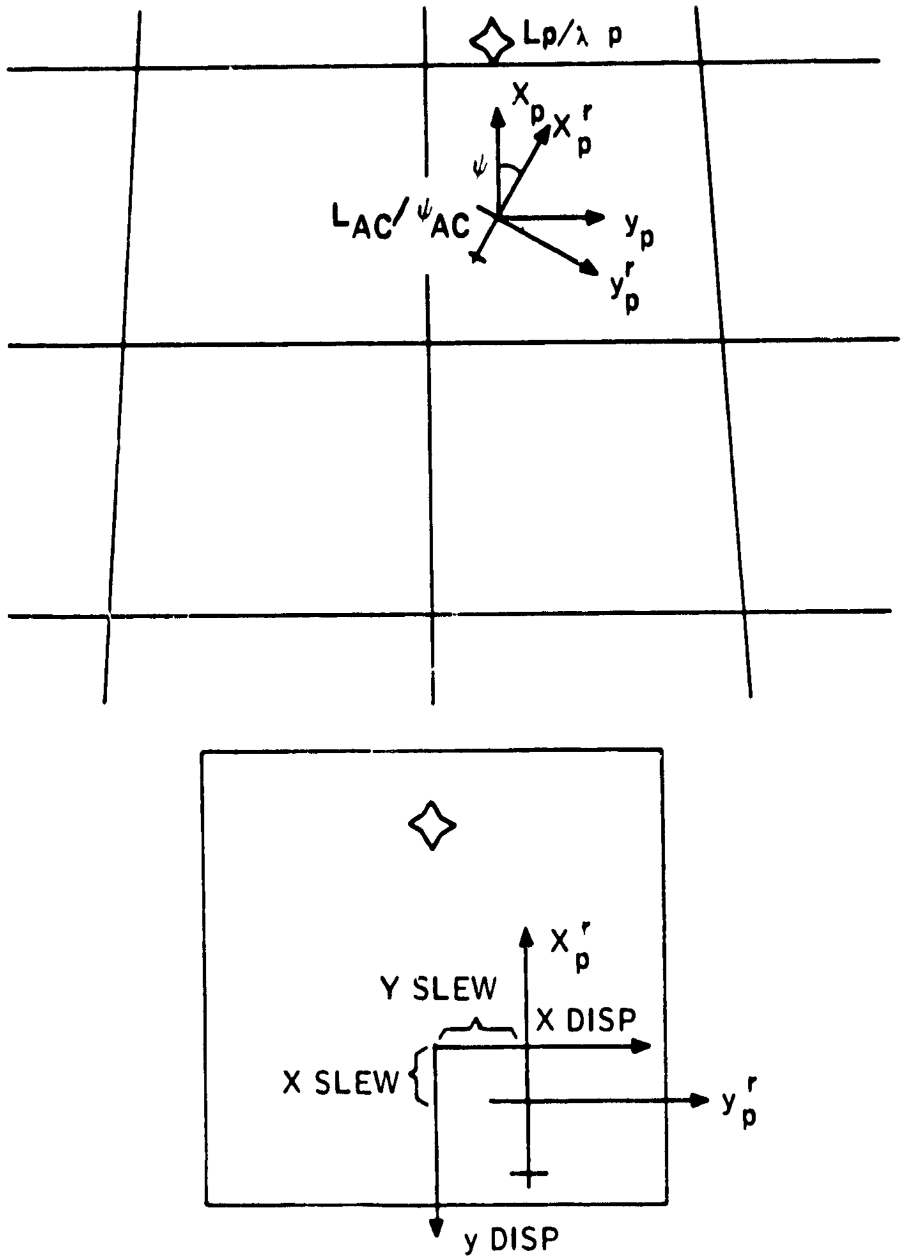


Figure 33. EHSI Map Slew

Map Review Implementation — Map review is entered if the MAP REVU button is depressed while the EHSI is in normal mode. In map review mode the map basis is the active waypoint instead of the aircraft, and at zero map slew, the map basis is centered on the display instead of slightly below the center of the display. The aircraft symbol is not shown in MAP REVU mode.

In heading-up mode the map will be oriented as the aircraft is oriented, and the map will rotate around the active waypoint as the aircraft turns.

Cursor Slew Implementation -- The cursor is mainly used to move waypoints and therefore, the cursor slew has to be map oriented. That is it has to keep its radial and distance relative to the active waypoint, independent of the map modes and the map scales. Cursor position displacement components are computed as described above.

Gain factors g_{up} and g_{left} are controlled by the slew stick. Gain factor $g_{up} = g_{left} = 0, 0.2, 1$ inch/sec depending on the slew controller displacement. If the EHSI is in the heading-up mode, these gain factors are rotated to:

$$g_{north} = \text{map scale} \cdot (g_{up} \cdot \cos\psi + g_{left} \cdot \sin\psi)/60 \text{ deg/sec}$$
$$g_{west} = \text{map scale} \cdot (-g_{up} \cdot \sin\psi + g_{left} \cdot \cos\psi)/60 \text{ deg/sec}$$

If EHSI is in north-up mode, we have:

$$g_{north} = \text{map scale} \cdot g_{up}/60 \text{ deg/sec}$$
$$g_{west} = \text{map scale} \cdot g_{left}/60 \text{ deg/sec}$$

The cursor position is then computed as:

$$L_c = L_{AWP} + \int_0^t g_{north} \cdot dt$$

$$\lambda_c = \lambda_{AWP} + \int_0^t g_{west}/\cos L_c \cdot dt$$

where L_c, λ_c is the lat-long of the cursor, L_{AWP}, λ_{AWP} is the lat-long at the active waypoint.

Integration is reset to zero when the EHSI exits the cursor mode and g_{up}, g_{left} are forced to zero when EHSI is not in cursor mode.

Lateral Beam Capture Logic — DAAS simulation studies prompted development of improved logic for transitioning from inbound to outbound courses at waypoints. The resulting lateral beam capture is as follows. Lateral beam capture flag becomes true when:

$$K_{y\Gamma} = \frac{U_1^2}{g \tan 25^\circ} \left\{ \left[\mathrm{sign}\,\Gamma\right] \left[1 - \cos(\psi - \mathrm{Crs\ Sel})\right] - \left(\frac{W}{57.3} U_1\right) \left[\psi - \mathrm{Crs\ Sel} + \tan^{-1}\left(\frac{W}{U_1}\right)\right] \right\}$$

where

$K_{y\Gamma}$	=	lateral displacement from selected course (positive to right of course) - ft
U_1	=	true airspeed - ft/sec
Crs Sel	=	Crs 1 or Crs 2 as appropriate - degrees
ψ	=	Airplane heading - degrees
W	=	Component of wind that is normal to selected course (positive when wind vector points to right of course) - ft/sec

When flying course 1 of an RNAV waypoint and course 2 is selected manually, the autopilot will revert to the heading hold mode until the capture flag becomes true. If the capture flag for course 2 had become true prior to manual selection of course 2, a capture turn will be initiated immediately.

When flying course 1 of an RNAV waypoint and auto sequence has been selected, the capture criterion for course 2 is examined while tracking course 1. When the capture flag becomes true, the autopilot initiates a turn to capture course 2 and the system automatically sequences to course 2 provided the time to the waypoint is less than 60 seconds. Should the time to go be greater than 60 seconds, the capture turn and auto sequence step will be delayed until the time to the waypoint is 60 seconds.

5.2.3 Navigation/Flight Planning Function Interfaces

Navigation/Flight Planning Function Interfaces are shown in Figure 34. The navigation/flight planning function receives flight plan and NAVAID data from the IDCC. Selected VORTAC frequency is sent to the radio adapter unit which tunes the selected NAV receiver and DME, and responds with extracted radio position information. Heading and true airspeed information are blended with radio position data in the

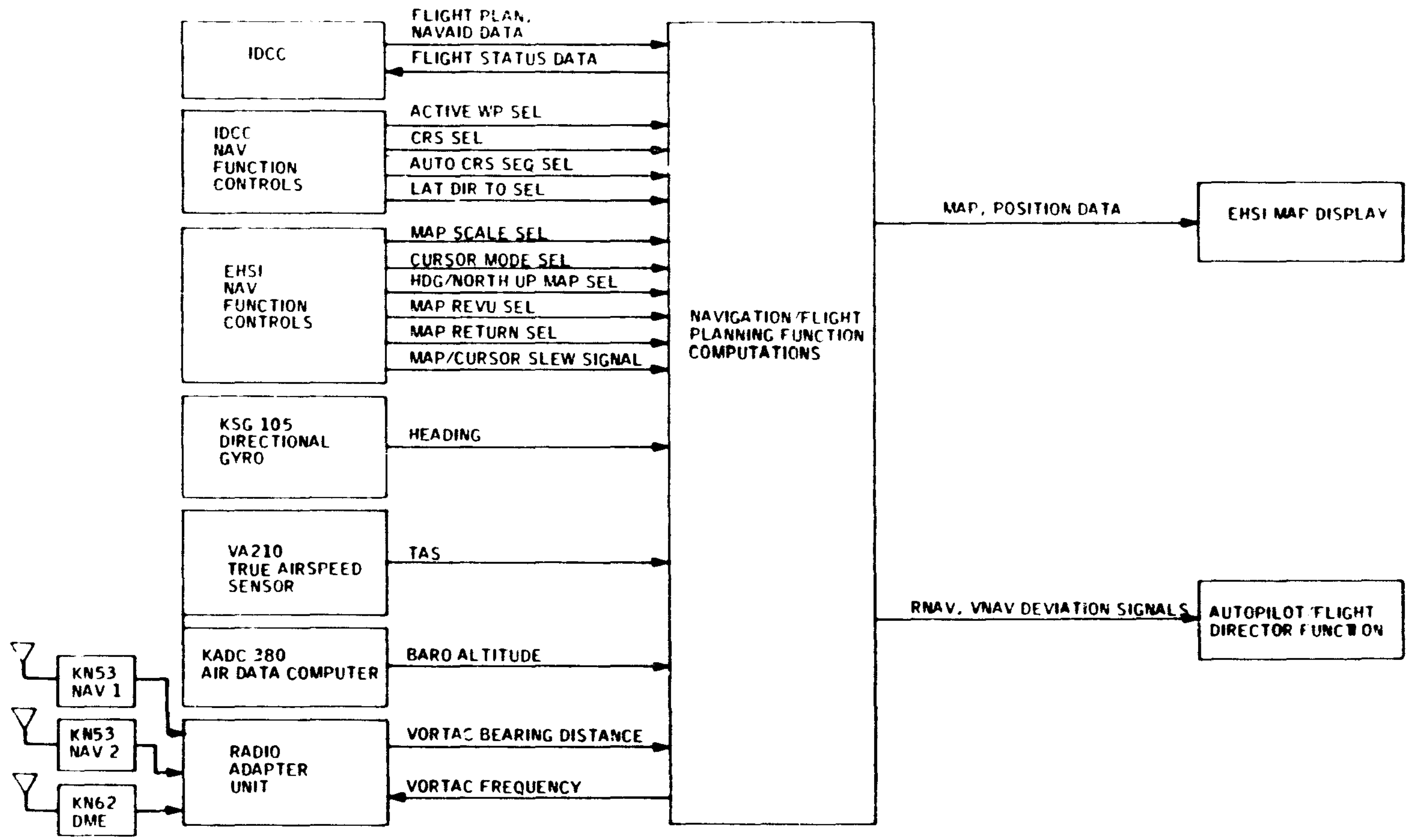


Figure 34. Navigation/Flight Planning Function Interfaces

navigation computations. Results of the Navigation/Flight Planning computations are displayed on the EHSI moving map, and deviation signals are supplied to the Autopilot/Flight Director Function for guidance.

5.3 VERTICAL NAVIGATION (VNAV) FUNCTION

The vertical navigation mode provides computed pitch commands to maintain a defined vertical path. To operate in this mode, the pilot must:

1) Establish an RNAV waypoint
2) Establish his course
3) Be on course laterally (see paragraph 5.4.8.1)
4) Set waypoint altitude on WP DATA page
5) Set along track offset from 0 to +50 NM if it is desired to reach the desired altitude before the waypoint.

EHSI and IDCC displays associated with VNAV are shown in Figure 35. The VTA indicator on the EHSI shows the track angle required to arrive at the active waypoint (with due consideration to offsets) at the waypoint altitude as entered on the WP DATA page. By pushing the VNAV button, the system will become coupled to that angle provided that the aircraft is laterally on course, and vertical track angle is within $-5 <$ VTA $< +2$ degrees. Altitude deviation from track (± 500 ft full scale) is displayed on the right hand scale of the FDI. Upon reaching the waypoint altitude, the system will revert to altitude hold.

VNAV is monitored at VNAV mode engagement to preclude inadvertent large pitch commands. Autopilot/Flight Director VNAV mode engage and disengage criteria are defined in paragraph 5.4.8.

5.4 FLIGHT WARNING/ADVISORY FUNCTION

The DAAS Flight Warning/Advisory Function include the following elements:

- Engine parameter monitoring, warning
- Aircraft configuration monitoring, warning
- Ground proximity monitoring, warning
- Airspeed and stall monitoring, warning

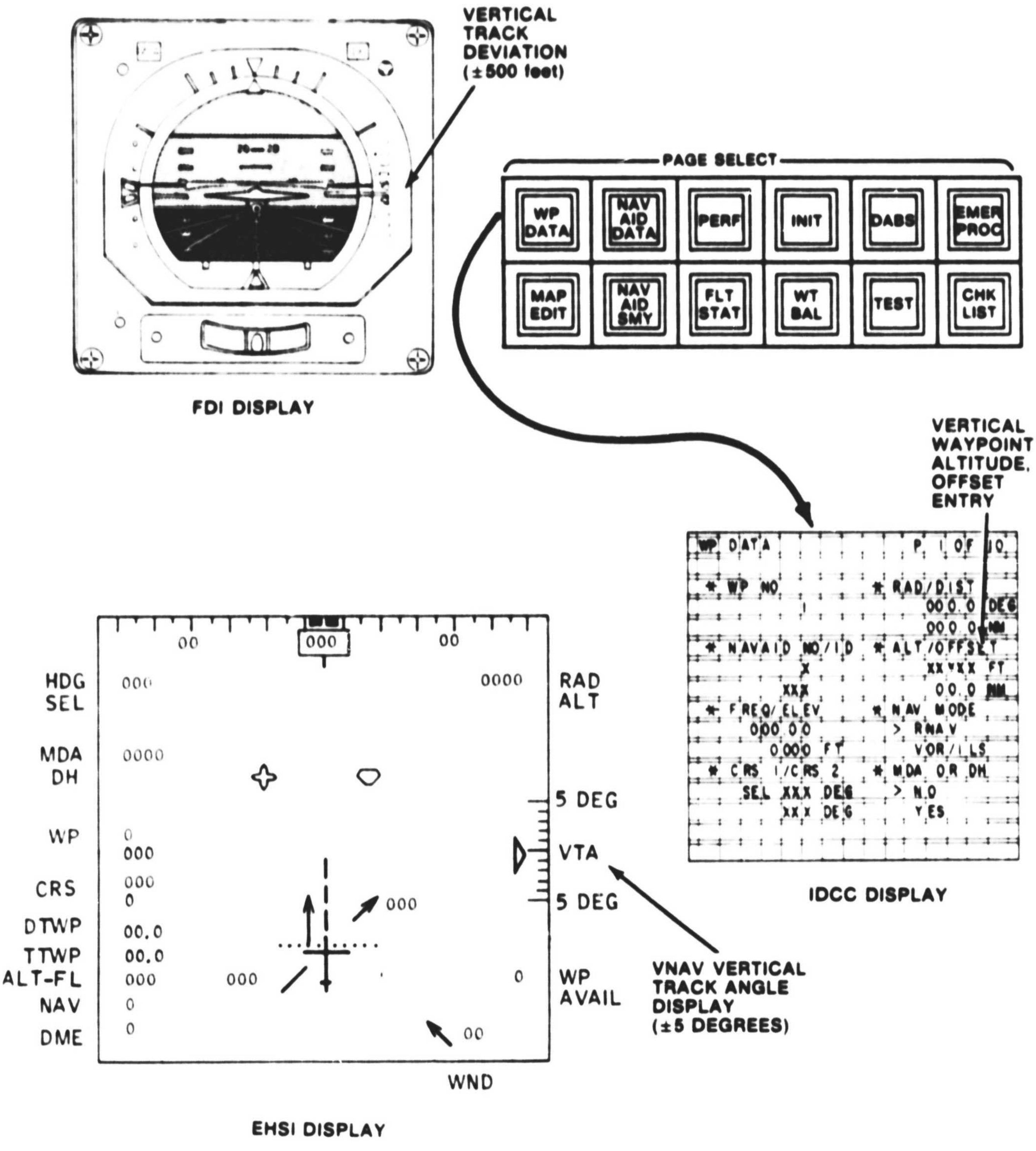


Figure 35. VNAV Displays

- Altitude advisory function
- Marker beacon advisory function
- NAVAID identification monitoring, warning
- Autopilot/flight director monitoring, warning
- BIT fault warning

The Flight Warning/Advisory Function controls and displays are shown in Figure 36. A red or amber flashing light annunciates a warning or caution, respectively. The associated text message appears on the 32-character, second-from-bottom line of the IDCC display. A pushbutton MSG ACK button is used to acknowledge the message and extinguish the flashing light. The red warning light is used for ground proximity warning, never-exceed speed warning, and autopilot disengage warning; and the amber light is used to annunciate caution situations generally according to Table 3. MDA and DH annunciation lights on the FDI, an altitude alert light on the altimeter, and an aural horn are used in the altitude advisory function.

Airway, outer and middle marker beacon lights are included to the right of the FDI.

IDCC warning or caution messages are retained until the conditions goes away. The retained warning or caution messages are stored according to one of the following three classifications:

- Unacknowledged warning messages
- Unacknowledged caution messages
- Acknowledged warning or caution messages

If any unacknowledged warning messages exist, the red warning light will be lit and the first received warning message will be displayed on the warning and caution message line on the IDCC. If the MSG ACK button on the IDCC is depressed, the displayed warning message will be transferred to an acknowledged message storage location (bottom of stack) and the next unacknowledged warning message is brought to the IDCC display. If no unacknowledged warning messages exist, the red warning light will extinguish and the first received unacknowledged caution message is displayed. If no unacknowledged caution messages exist, the message at the top of the acknowledged messages stack is displayed.

Table 3. Flight Warning System

Warning Function/Parameter	Warning Light Red	Warning Light Amber
1) Engine Parameter Monitoring		
Manifold Pressure		X
Engine RPM		X
2) Configuration Monitoring		
Doors		X
Landing Gear		X
Wing Flaps		X
Cowl Flaps		X
Trim		X
Aux Fuel Pumps		X
3) Ground Proximity Warnings	X	
4) Airspeed/Stall Warnings 1.2 V_{STALL}		X
V_{NE} (never exceed)	X	
V_{ND} (max cruise)		X
5) Autopilot Disconnect	X	

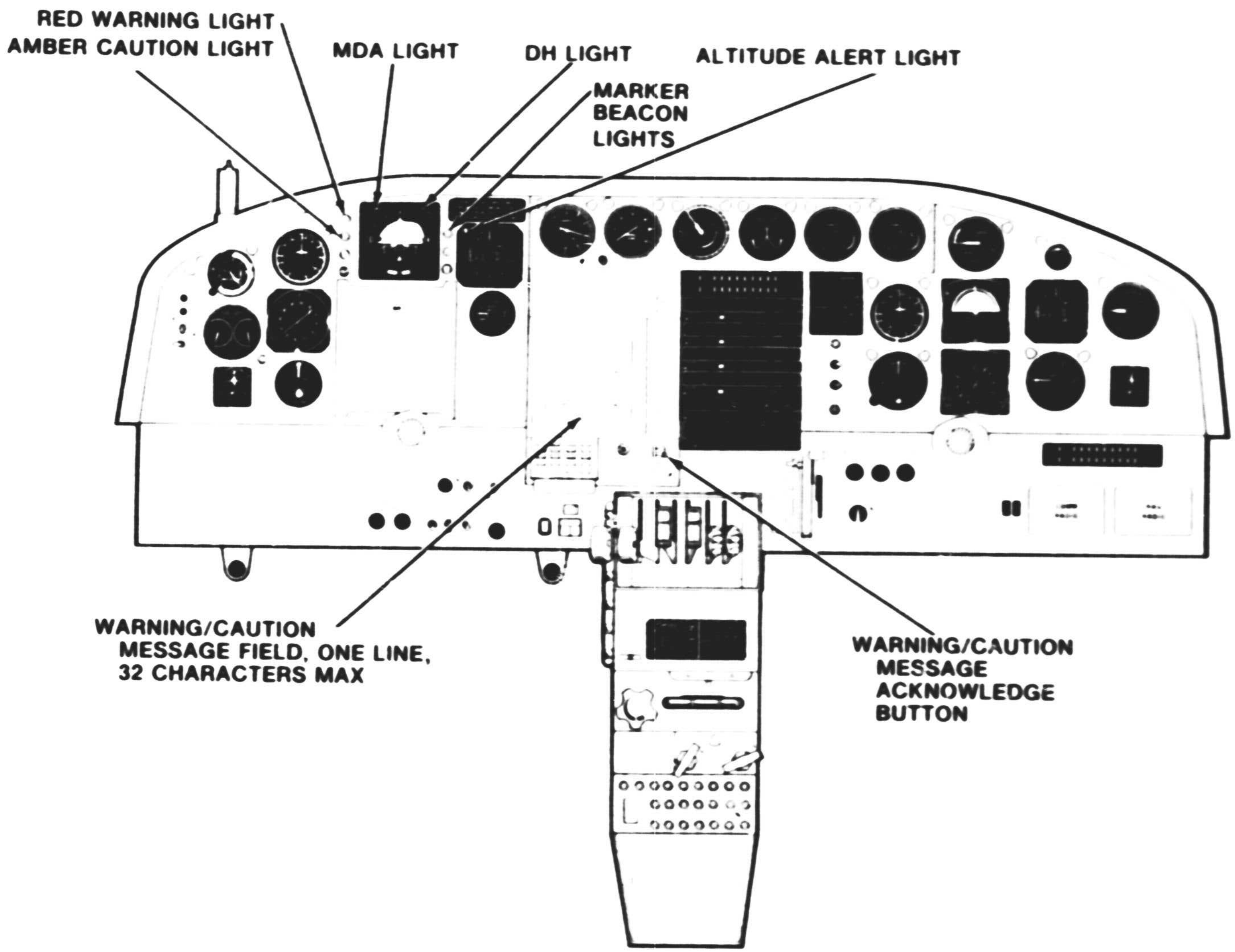


Figure 36. DAAS Flight Caution Function Controls and Displays

Unacknowledged caution messages are presented and acknowledged in the same way as unacknowledged warnings. Caution messages are second in priority to unacknowledged warning messages. The amber caution light is extinguished whenever all caution messages are acknowledged.

Acknowledged warning or caution messages are stored in a stack until such time as the causitive conditions cease to exist. If all warning and caution messages are acknowledged, both the red and the amber lights are extinguished, but the pilot can sequence through the messages that are still current by subsequent pushing of the message acknowledge button. Once a warning has been acknowledged, the system no longer retains knowledge of that message's priority. IDCC warnings and associated lights will extinguish automatically prior to pilot acknowledgement if the warning conditions are removed.

Following is a description of the various Flight Warning/Advisory Function elements.

5.4.1 Engine Parameter Monitoring, Warning

The Engine Parameter Monitoring function provides two types of continuous engine monitoring: manifold pressure, and RPM. An appropriate caution is displayed at the bottom of the IDCC for out-of-tolerance conditions. A description of the warning conditions and corrective advisories for operational monitoring follows.

5.4.1.1 **Manifold Pressure (MAP)** — Three conditions of manifold pressure will generate pilot warnings:

Full Power MAP — In full power flight at takeoff or maximum climb, the maximum MAP of 34.5 inches Hg may not be exceeded. (Valid to altitudes of 16,000 feet).

Warning Logic: (MAP > 34.5 inches Hg)

IDCC Message: HI MAN PRES (RE, LE, BE) RE, LE, BE refers to Left Engine, Right Engine, Both Engines respectively, throughout.

Warning/Caution Light: Amber

Normal Operating MAP — In normal operating conditions (less than 75% power) the maximum recommended MAP is 29.5 inches Hg except as noted above in the conditional normal operating case.

Warning Logic: RPM < 2600
AND (MAP > 29.5 inches Hg)

IDCC Message: HI MAN PRES (RE, LE, BE)

Warning/Caution Light: Amber

5.4.1.2 Engine RPM — The RPM is continuously monitored and warning given if the maximum RPM limit is exceeded.

Warning Logic: (RPM > 2700)

IDCC Message: HI RPM (RE, LE, BE)

Warning/Caution Light: Amber

5.4.2 Aircraft Configuration Monitoring, Warning

The aircraft configuration monitoring continuously checks the position of the doors, landing gear, cowl flaps, wing flaps, boost pumps, and trim as a function of aircraft state as defined in Table 4.

The warning messages for the aircraft configuration monitor are as follows:

Configuration Item	IDCC Message	Warning/Caution Light
1. Door	DOOR NOT LATCHED	AMBER
2. Landing Gear (In Flight)	LDG GEAR DOWN	AMBER
(Final Appr)	LDG GEAR UP	AMBER
3. Cowl Flaps (Taxi-Takeoff)	COWL FLAPS CLOSED	AMBER
4. Wing Flaps (All except Appr)	WING FLAPS DOWN	AMBER
(Final Appr)	WING FLAPS UP	AMBER
5. Aux Fuel Pumps	AUX FUEL PUMPS OFF	AMBER
6. Trim (Takeoff)	OUT OF TRIM	AMBER

Table 4. Aircraft Configuration Monitoring

Pilot Will be Alerted on IDCC Upon Occurrence of Any of the Following Conditions							
A/C State	A/C Config.	Doors	Gear	Cowl Flaps	Wing Flaps	Aux Fuel Pumps	Trim
Taxi	Wt on Gear > 30 sec RPM < 2000	Not Latched		Not Open Full	Not Up		
Run Up Takeoff	Wt on Gear > 30 sec RPM > 2000	Not Latched		Not Open Full	Not Up	Not On	Not at T/O Setting
Lo-Alt Flight	KIAS > 130 KTS ALT < 12,000	Not Latched	Down		Not Up		
Hi-Alt Flight	KIAS > 130 KTS Alt > 12,000 Ft	Not Latched	Down		Not Up	Not On	
Final Approach	KIAS <104 KTS MAP < 20 IN Hg	Not Latched	Up		15°	Not On	

5.4.3 Ground Proximity Monitoring, Warning

The Ground Proximity Warning (GPW) function employs the ARINC 594-1 Mode algorithms. Warning is based on radar altitude and barometric altitude rate according to Figure 37.

The DAAS GPW required baro altitude rate is derived from the encoding altimeter (altitude signal) and radar altitude from the Sperry RT-221 radar altimeter (precision output signal accuracy: ±3 ft at 0-100 ft; ±3% at 100-500 ft; ±4% at 500-2500 ft.)

5.4.4 Airspeed and Stall Monitoring, Warning

The airspeed/stall warning function will detect 1.2 Vstall from angle of attack. Occurrence of 1.2 Vstall will cause the amber caution light to flash and generate the following message on the IDCC warning line: 1.2 VSTALL.

In addition to stall warning, if maximum structural cruise speed, V_{ND} (199 KIAS) is reached, the amber caution light is flashed and the following IDCC message is generated: MAX CRUISING AIRSPEED.

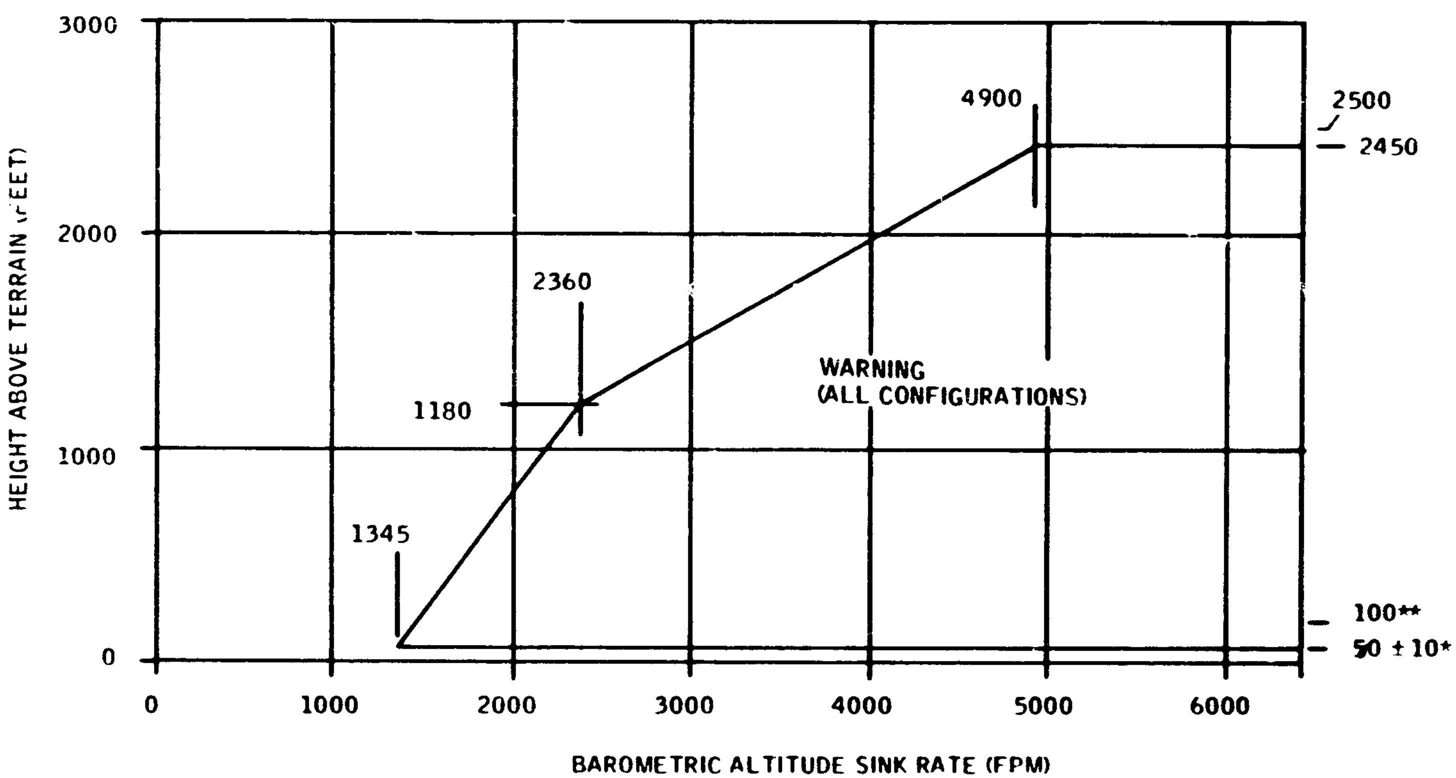
If the never-exceed airspeed V_{NE} (230 KIAS) is reached, the red warning light is flashed and the following IDCC warning is generated: NEVER EXCEED AIRSPEED.

5.4.5 Altitude Alert Function

The altitude alert function will alert the pilot when approaching a reference altitude. Alerting is accomplished by the altitude alert light on the altimeter, the MDA and DH lights on the ADI, and an aural tone generator (see Figure 36).

The altitude alert light and aural warning are armed when the active waypoint has an entered altitude, or autopilot/flight director ALTITUDE HOLD is engaged. The reference altitude for altitude alerting is the IDCC WP DATA page active waypoint altitude as indicated in Figure 38, or the ALTITUDE HOLD reference if ALTITUDE HOLD is engaged. The ALTITUDE HOLD reference takes precedence. Altitude alerting criteria is indicated in Figure 39. The altitude alert light (and associated horn) is inactive if MDA or DH is selected, unless the autopilot/flight director altitude hold is engaged.

EXCESSIVE RATE OF DESCENT WITH RESPECT TO TERRAIN



MODE I IS FUNCTIONAL AT ALL TIMES
* DESCENT INHIBIT HEIGHT
** MAXIMUM ASCENDING ARMING HEIGHT

Figure 37. DAAS Ground Proximity Warning Criteria

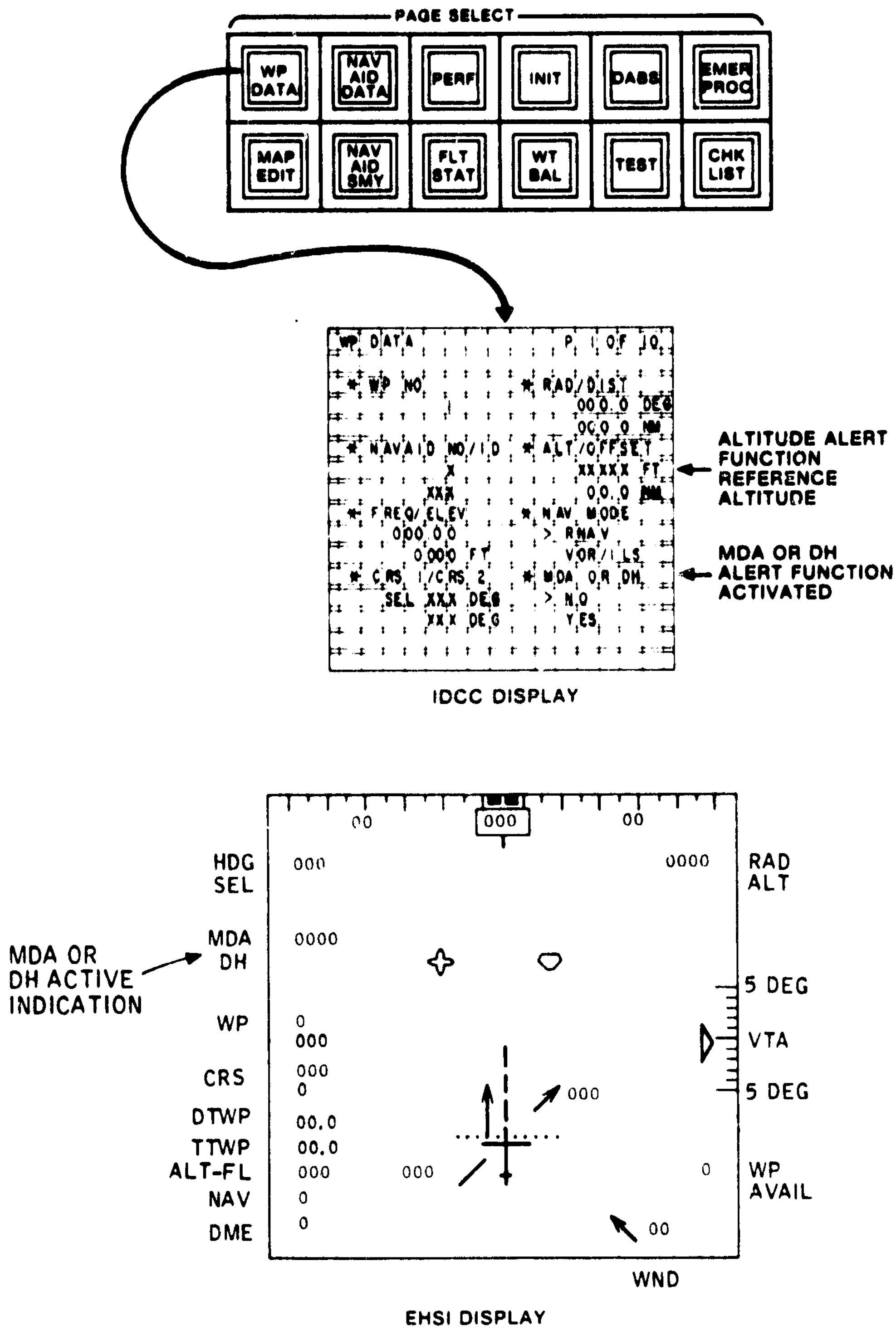


Figure 38. Altitude Alert IDCC Controls and Displays

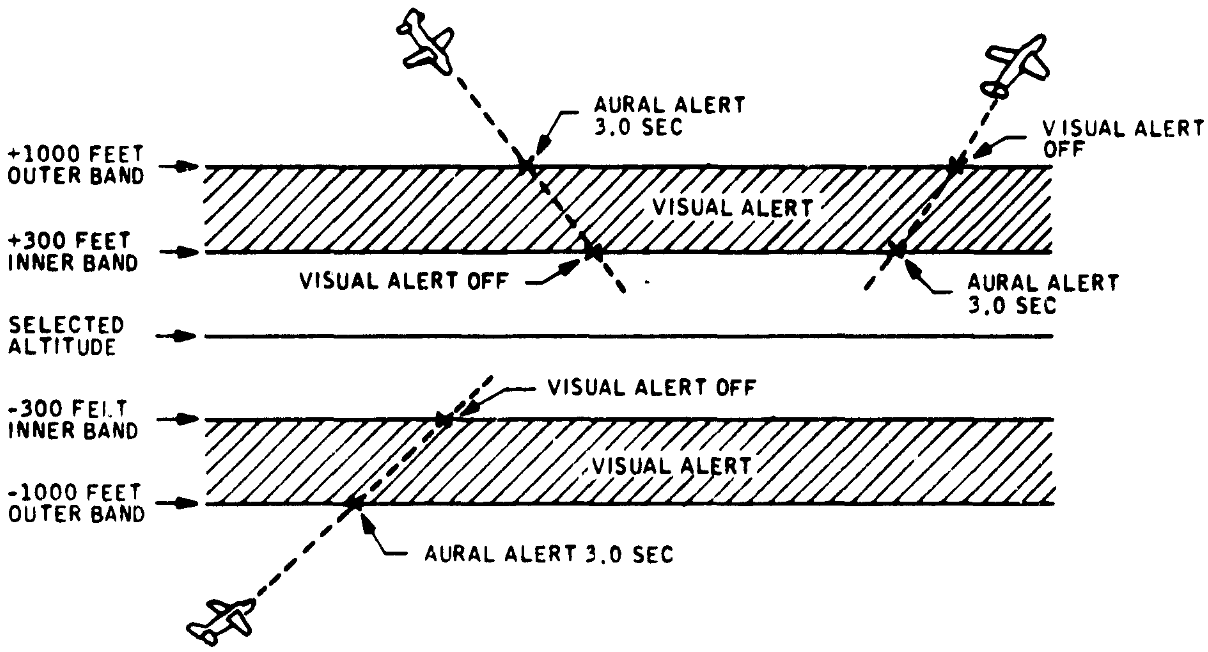


Figure 39. Altitude Alert Function Alerting Criteria

MDA or DH alert lights are armed when MDA or DH is indicated on the IDCC WP DATA page as indicated in Figure 38. The MDA light or DH light will be activated when passing through the active waypoint altitude for RNAV/VOR approach or ILS approach respectively, when MDA or DH is selected on the IDCC WP DATA page. When active, the MDA or DH magnitude is also displayed on the EHSI left side (see Figure 38).

5.4.6 Marker Beacon Advisory Function

The KMA 24 Audio Panel includes a marker beacon receiver that controls lighting of the white airway marker light, blue outer marker light, and amber middle marker light shown in Figure 36. The airway marker will light and a 3000-Hz tone is generated when the aircraft passes over an airway marker or runway threshold. The outer marker passage is identified by flashes of the blue outer marker light at 2 Hz, with an accompanying 400-Hz audio series of dashes, also at 2 Hz. The outer marker is normally positioned on the front localizer where the glideslope intersects the minimum inbound altitude, usually at 7 miles out. The middle marker, normally about 3200 feet from the approach end of the ILS runway, is identified by flashes from the amber light accompanied by alternating 1300-Hz audio dots and dashes.

The marker beacon tone is controlled using the KMA 24.

5.4.7 NAVAID Identification Monitoring, Warning

The Morse code transmitted by the VOR and DME ground stations is decoded and converted to ASCII for transmission to the DAAS central computer. The process for accomplishing this is as follows. The audio tone put out by the NAV receivers is converted to a digital signal representing the tone envelope. In the case of DME this is accomplished through a diode detector operating on the signal which has first been processed through a bandpass filter. In the case of VOR the sine wave tone is bandpassed and then fed to a tone decoder. The tone decoder output is conditioned using two monostable multivibrators.

The envelope signal is then processed to decode the dots and dashes. The length of the dot or dash is compared to a nominal time period. Those longer than nominal are stored as ones (dashes) and those shorter are stored as zeros (dots). The digitized Morse code thus obtained is used as an address for a ROM look-up table. The ASCII code obtained from the look-up table is then further formatted by the RAU CPU for transmission to the central computer.

If the NAVAID ID is entered as part of the NAVAID data, DAAS will compare the decoded ID with the entered ID. Unless there is a match within 2 minutes after activation of the NAVAID, the amber light is flashed, and the IDCC message MORSE CODE MISMATCH is displayed.

5.4.8 Autopilot/Flight Director Monitoring, Warning

Autopilot/flight director monitoring includes:

- VNAV monitoring
- ILS approach monitoring
- Miscellaneous monitoring

Autopilot disengagement during flight is annunciated by a flashing red warning light, accompanied by an IDCC message AUTOPILOT INOP.

5.4.8.1 VNAV Mode Monitoring, Warning — The autopilot VNAV mode is monitored at engagement to preclude inadvertent large pitch commands. The following parameters are monitored at engagement:

1. Navigation RNAV mode engaged
2. Active waypoint altitude defined
3. Aircraft position with respect to active waypoint in acceptable region as indicated in Figure 40.

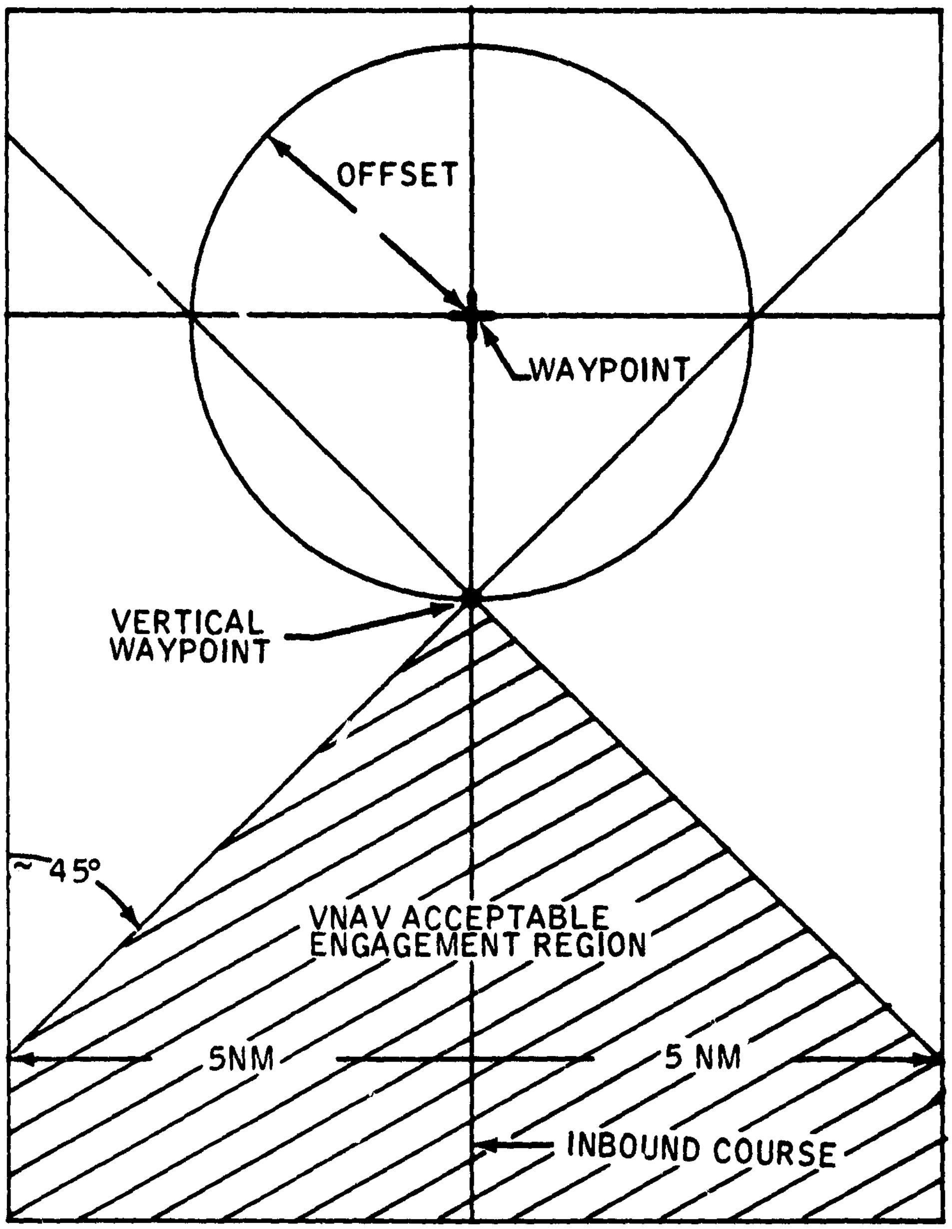


Figure 40. VNAV Mode Engagement Criteria

4. Vertical track angle $-5 < VTA < +2$ degrees

If any conditions are violated, engagement is inhibited and the yellow light is flashed and the warning message VNAV INVALID is displayed. VNAV disengagement occurs if conditions 1 through 3 are violated after engagement, or if the active waypoint is changed in any way. The autopilot/flight director reverts to altitude-hold/altitude-arm when so disengaged. No warning is given for VNAV disengagement.

5.4.8.2 Miscellaneous Autopilot/Flight Director Monitoring, Warning — The system monitors validity of the sensors, the DAAS computers, and the servoactuator control loops to alert the pilot when information is faulty and when the system is not responding correctly to command signals.

Invalid signals provide both visual warning and inhibit signals, which are routed to the switching logic to "lock out" modes that will not operate reliably. Visual warnings are provided by flags and annunciators. This not only warns the pilot, but also makes it impossible to engage the system in a mode which has invalid information. For example, when vertical gyro failure exists, no modes can be selected and the autopilot cannot be engaged. Specific mode logic is defined in paragraph 5.1.

The DAAS autopilot is disengaged for the following conditions:

- Manual disengagement
- Manual electric trim on
- Autopilot dump switch on
- Trim monitor detects fault
- Excessive normal acceleration indicated
- BIT fault indication
  - Servo command wrap around test fail
  - Analog, discrete wrap around test fail
  - Servo test fail

BIT monitors and tests are described in paragraph 5.10.

DAAS autopilot disengagement is accompanied by the following warning indications:

- AUTOPILOT annunciator light is flashed 4 times at 1 Hz.
- Aural horn warning
- Red warning light, "AUTOPILOT INOP" IDCC warning message

5.4.9 BIT Fault Warning

DAAS inflight BIT monitors system operation and will detect faults which effect functional performance. Fault definition on the IDCC display is accompanied by a red or amber light depending on criticality of the fault. BIT fault warning messags and logic are defined in paragraph 5.10.

5.5 GMT CLOCK FUNCTION

The DAAS GMT clock function set and readout are indicated in Figure 41. The clock is initialized at power-on to 00:00, and can be set to correct time on the IDCC INIT page. The clock time is displayed on the INIT page, and on the FLT STAT page. FLT STAT page 2 waypoint ETA data is based on the GMT clock time.

5.6 FUEL TOTALIZER FUNCTION

DAAS continuously computes and displays aircraft gross weight and fuel remaining as depicted in Figure 42. Gross weight and fuel are initialized either directly on the INIT page, or initial values are transferred to the INIT page from the WEIGHT AND BALANCE function. Current values of fuel remaining and weight are the initial value minus the integral of measured fuel flow as determined from the ARC Fuel Flow Sensor. Weight and fuel computations are reinitialized whenever new initial values are input to the system.

Current values of fuel remaining are displayed on the IDCC FLT STAT page 1, and EFR values on FLT STAT page 2 are also based on the fuel totalizer computation.

Current aircraft weight can be transferred into the TAKEOFF PERFORMANCE or CRUISE PERFORMANCE page by use of the AUTO DATA ENTRY function.

The INIT page is the first page displayed at power-up. Appearance of the page indicates passage of power-up test, and cues the pilot to initialize clock and fuel totalizer computations.

5.7 WEIGHT AND BALANCE FUNCTION

Weight and balance function input/output IDCC displays are presented in Figure 43.

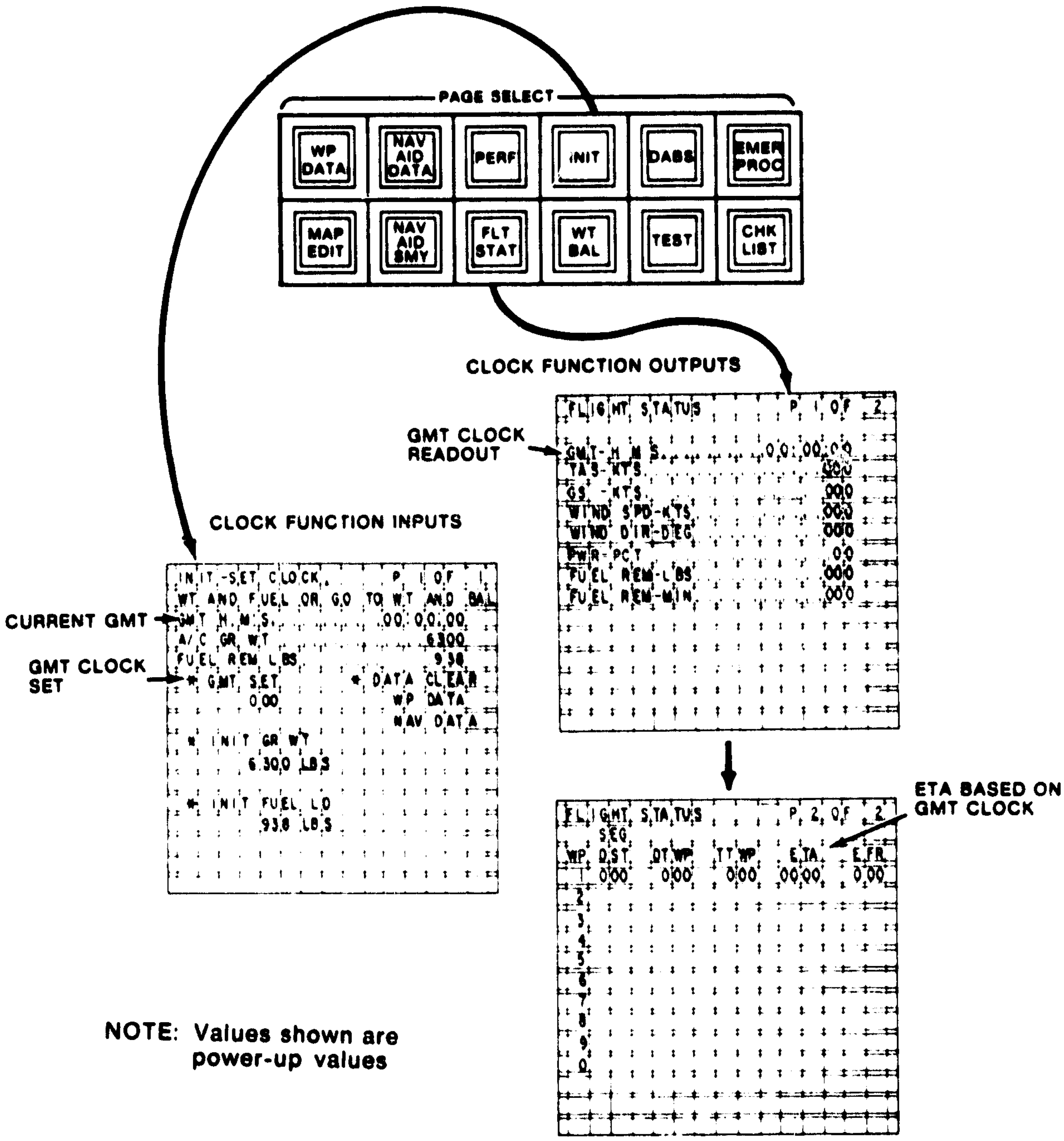
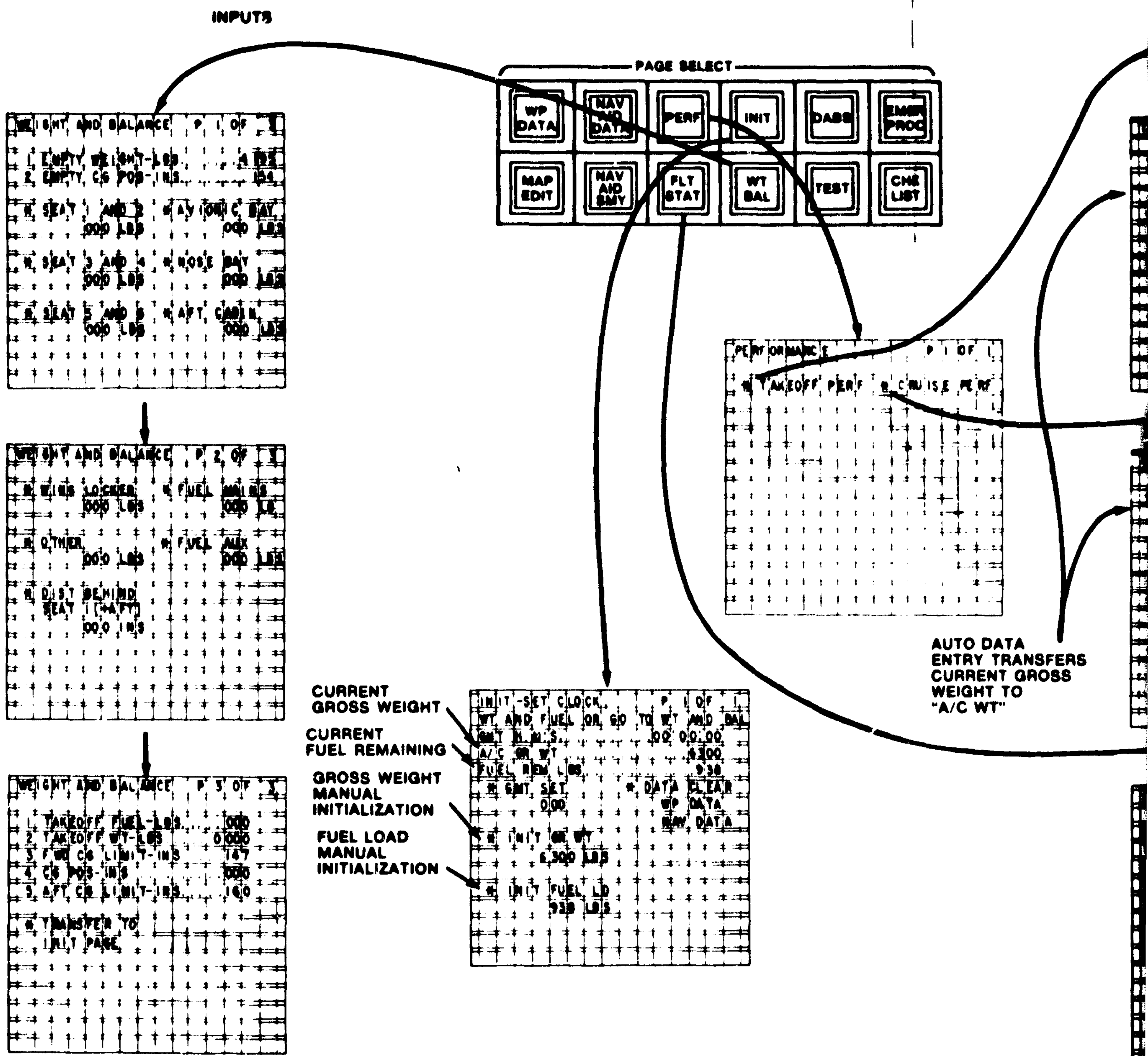


Figure 41. GMT Clock Function IDCC Controls and Displays



NOTE: Values shown are power-up values

FOLDOUT FRAME

OUTPUTS

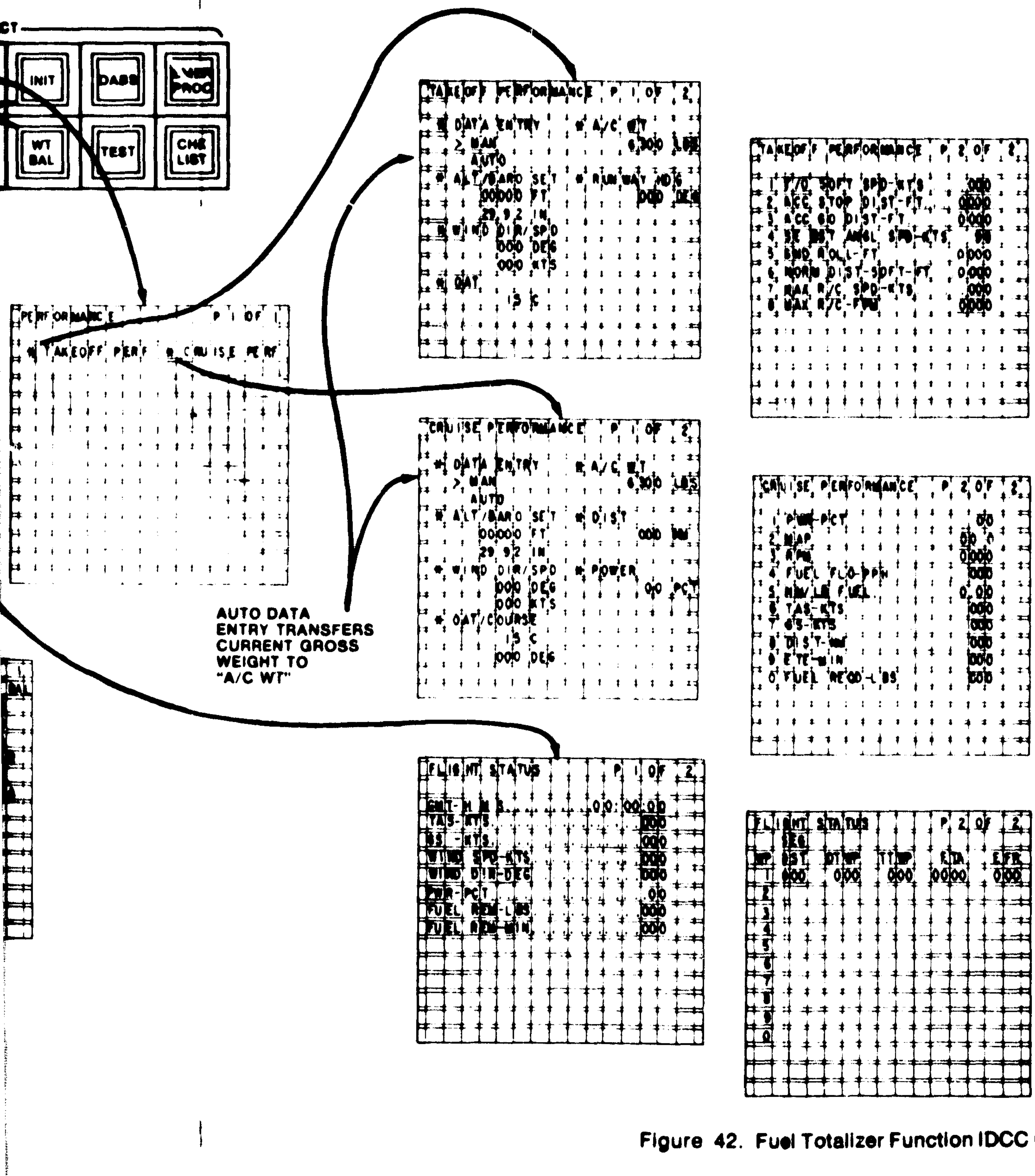


Figure 42. Fuel Totalizer Function IDCC Controls and Displays

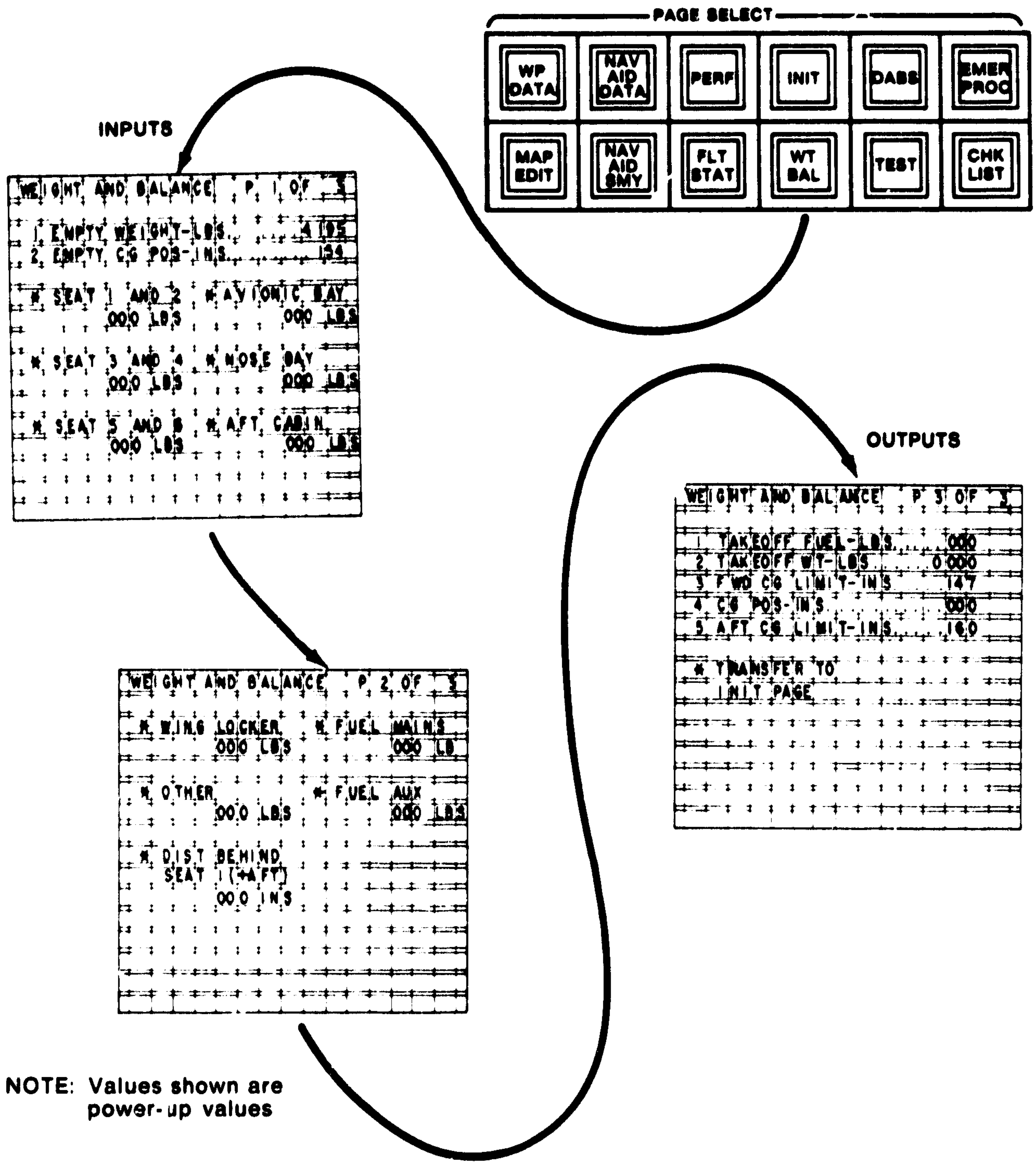


Figure 43. Weight and Balance Function IDCC Controls and Displays

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Computation algorithms are summarized in Table 5. Passenger, luggage and fuel weight can be entered on IDCC WEIGHT AND BALANCE page 1 and 2. Weight and location of an arbitrary object can also be entered on page 2, with location entered with respect to seat 1. Total aircraft weight, total fuel, and center-of-gravity position with respect to limits are presented on page 3.

Total weight and total fuel can be transferred to initialize the fuel totalizer function (INIT page) by using the bottom touchpoint on page 3.

5.8 PERFORMANCE, FUEL/DISTANCE/TIME COMPUTATION FUNCTION

Cessna 402B aircraft takeoff and cruise performance computation functions are included in DAAS. Cruise performance computation includes fuel/distance/time calculations for a defined trip segment. Following is a description of these performance computation functions.

5.8.1 Takeoff Performance

Takeoff performance input/output IDCC displays are shown in Figure 44. Computation algorithms are summarized in Table 6. The AUTO DATA ENTRY function on the IDCC TAKEOFF PERFORMANCE page 1 will continuously transfer sensed outside air temperature (OAT) and current aircraft weight into the performance computations. Other data must be entered manually. When in AUTO DATA ENTRY, it is not possible to manually enter OAT or A/C WT.

5.8.2 Cruise Performance, Fuel/Distance/Time Function

Cruise performance, fuel/distance/time input/output IDCC displays are shown in Figure 45. Computation algorithms are summarized in Table 7. The AUTO DATA ENTRY function on the IDCC CRUISE PERFORMANCE page 1 will continuously transfer sensed altitude, sensed wind direction and speed from the Kalman filter, sensed outside air temperature, and computed current aircraft weight into the performance computations. When AUTO DATA ENTRY is selected, it is not possible to manually enter these variables.

Fuel/distance time is computed for a trip segment when segment distance (DIST) is entered in the input data. Estimated time enroute (ETE) and estimated fuel required (FUEL REQ) are included in the cruise performance output data.

Table 5. Weight and Balance Function Algorithms

Inputs	Process	Outputs
IDCC INPUT DATA Fuel Main Fuel Auxiliary Wing Lockers Seat 1 & 2 Seat 3 & 4 Seat 5 & 6 Avionics Bay Nose Bay Aft Cabin Other Weight Distance Behind Seat 1 Coded Constants Empty Weight Empty Moment	Takeoff Fuel = Fuel Main + Fuel Aux. Takeoff Weight = Empty Weight + Takeoff Fuel + Seat 1 & 2 + Seat 3 & 4 + Seat 5 & 6 + Avionics Bay + Nose Bay + Aft Cabin + Other Wt	IDCC OUTPUT DATA Takeoff Fuel Takeoff Weight
	Forward Center of Gravity Limit If Takeoff Weight ≤ 5000 Then Forward Limit = 147 49 Else Forward Limit = 147 49 + 00252 X (Takeoff Weight - 5000)	Forward Center of Gravity Limit
	AFT Center of Gravity Limit If Takeoff Weight ≤ 5900 Then Aft Limit = 160.20 Else Aft Limit = 160 20 - 00125 X (Takeoff Weight - 5900)	AFT Center of Gravity Limit
	Center of Gravity = (Empty Moment + 152 X (Fuel Main) + 164 X (Fuel Aux) + 186 X (Wing Lockers) + 137 X (Seats 1 & 2) + 175 X (Seats 3 & 4) + 218 X (Seats 5 & 6) + 32 X (Avionics Bay) + 71 X (Nose Bay) + 266 (Aft Cabin) + (Distance Behind Seat 1 + 137) X (Other Weight)] / Takeoff Weight	Center of Gravity

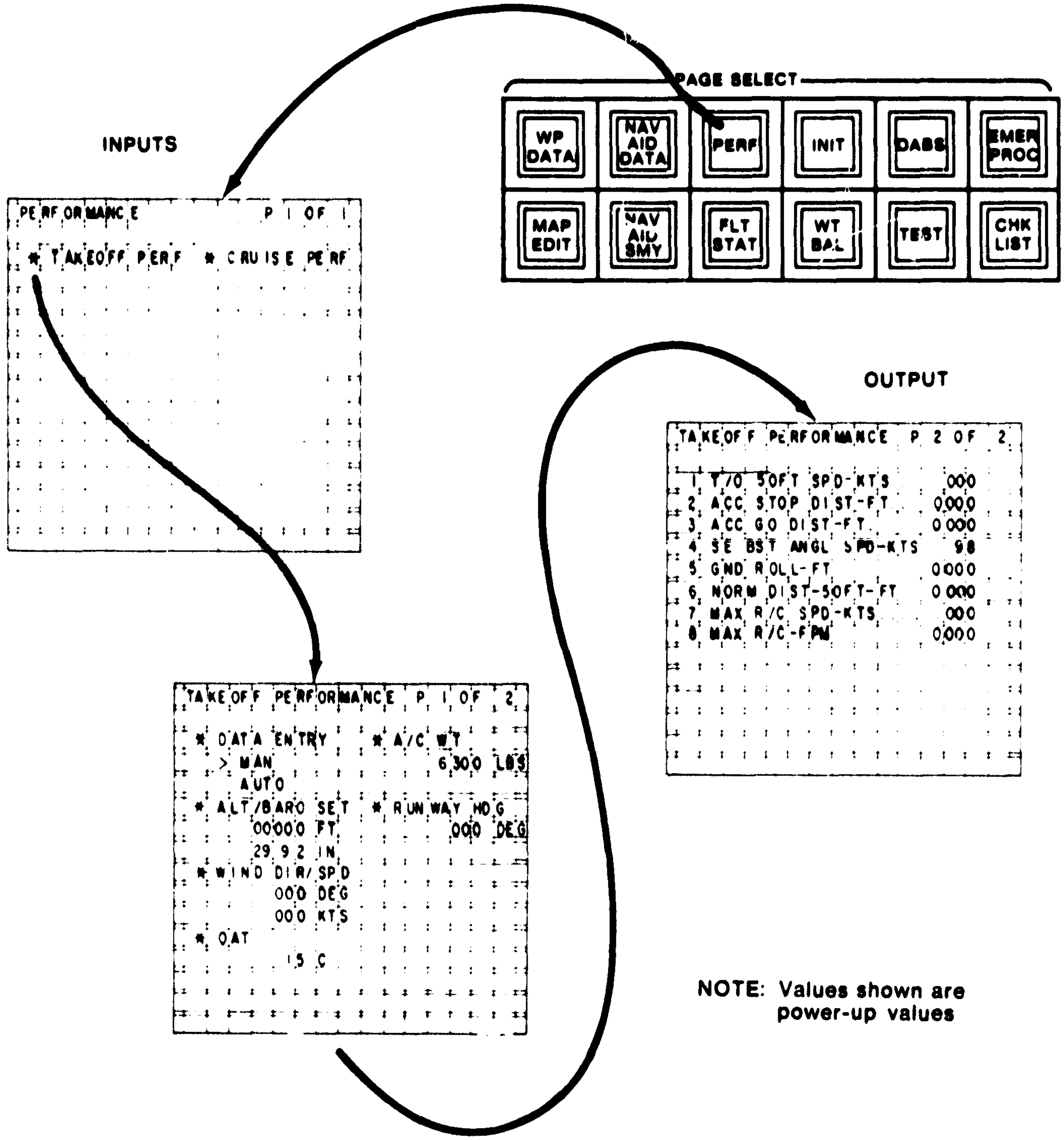


Figure 44. Takeoff Performance Function IDCC Controls and Displays

Table 6. Takeoff Performance Algorithms

Inputs	Process	Outputs
-Altitude -Barometer -Wind Direction -Wind Speed -Outside Air Temp. -A/C Wt (T/O performance or initialization) -Runway Heading	-Altitude = Field Elevation + 922.9 X (29.9 - Pressure) -Wind Correction Head wind = Wind Magnitude X COS (Wind Direction - Runway Heading) If Headwind 0, Wind Correction = .0075 x Headwind (+) Else Wind Correction = .025 X Headwind (-)	T/O - 50 ft Speed Accelerate - Stop Distance *Accelerate - Go Distance Single Engine Best Angle Speed Ground Roll Normal Distance to 50 Feet Max Rate of Climb Speed Max Rate of Climb
Sensor Input -Outside Air Temperature	-Takeoff - 50 ft Speed = .008 X A/C Weight + 40.6 -Distance to Clear 50 ft = Distance to Clear 50 ft (Pilot's Operational Handbook) X (1-Wind Correction) -Ground Roll Distance = Ground Roll (Pilot's Operational Handbook) X (1-Wind Correction) -Accelerate Stop Distance = Accelerate Stop Distance X (1-Wind Correction) -Max Rate of Climb Speed = 47.9 + .0097 X A/C Weight -Max Rate of Climb (feet/min) = Max Rate of Climb (feet/min) (Pilot's Operational Handbook) -Single Engine Best Angle Speed = 98 KTAS	

*Accelerate-Go Distance Algorithm Not Yet Defined.

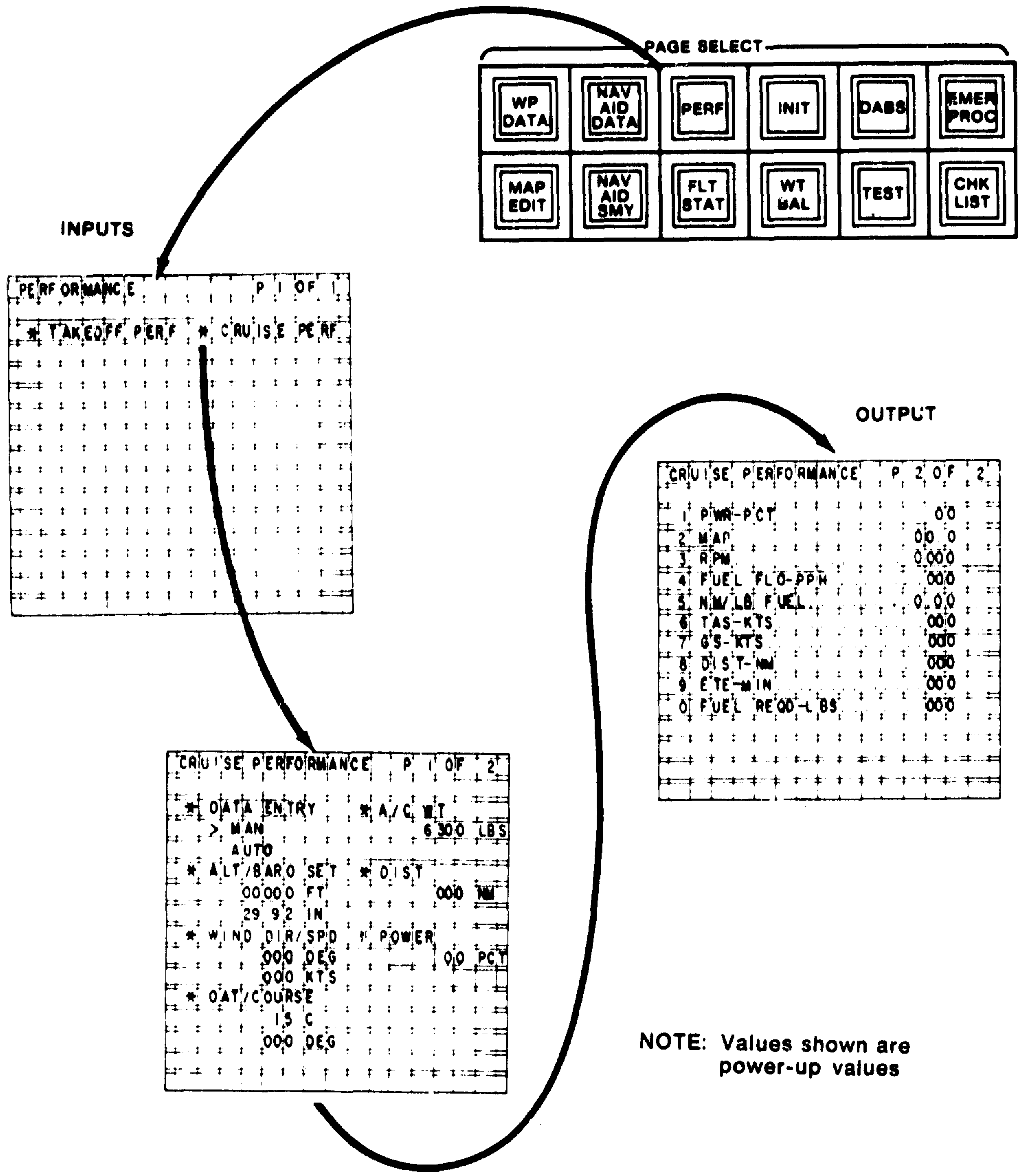


Figure 45. Cruise Performance Fuel/Distance/Time Function IDCC Controls and Displays

Table 7. Fuel Performance, Fuel/Distance/Time Function Algorithms

Inputs	Process	Outputs
IDCC Inputs - Altitude - Barometer - Wind Direction - Wind Speed - Outside Air Temperature - Course - Aircraft Weight - Distance - Power Sensor Inputs - Altitude - Outside Air Temperature Kalman Filter Inputs - Wind Direction - Wind Speed	Computation of RPM, MAP, and TAS From Percent Power Cruise Altitude = Altitude + 922.9 (29.92 - Baro) Corrected Power = .01 X Power X $\left[1 + .003\left(\text{OAT}-15+\frac{\text{Cr. Alt.}}{500}\right)\right]$ If corrected power ≤ .61 Then corrected power = Corrected Pow. -1.5×10^{-6} X Altitude Case 1 Corrected Power ≤ .606 RPM = 2100 MAP = 12.11 X EXP (1.468 X Corrected Power) + .7 Corrected TAS = 166 X Corrected Power + 57 Case 2 .606 < Corrected Power ≤ .650 RPM = 2200 MAP = 12.12 X EXP (1.366 X Corrected Power) + .7 Corrected TAS = 126 X Corrected Power + 77 Case 3 .650 < Corrected Power ≤ .692 RPM = 2300 MAP = 12.14 X EXP (1.284 X Corrected Power) + .7 Corrected TAS = 122 X Corrected Power + 81 Case 4 .692 < Corrected Power ≤ .753 RPM = 2450 MAP = 12.16 X EXP (1.177 X Corrected Power) + .7 Corrected TAS = 103 X Corrected Power + 94 TAS = corrected TAS + $\frac{6300 - \text{GWT}}{200} + \frac{\text{Altitude}}{670} - \frac{\text{Temp} - 15}{10}$ Fuel Flow Rate (Lbs/Hr) If Power < 60% Then Fuel Flow = 2.12 X Power (%) + 40.5 Else Fuel Flow = 2.45 X Power (%) + 20.7 Relative Wind Angle (RWA) = Course - Wind Direction Ground Speed = SQRT $\{\text{TAS}^2 - [\text{Wind Speed} \times \text{SIN (RWA)}]^2\}$ - Wind Speed X COS (RWA) NM/LB Fuel = Ground Speed/Fuel Flow Rate Estimated Time Enroute (Min) = 60 Min/Hr X Distance/Ground Speed Estimated Fuel Required = $\frac{\text{Estimated Time Enroute}}{60 \text{ Min/Hr}}$ X Fuel Flow Rate	MAP RPM Fuel Flow NM/LB Fuel TAS Ground Speed Estimated Time Enroute Estimated Fuel Required

5.9 DABS FUNCTION

The DABS function as incorporated in the DAAS system is intended to provide a demonstration test bed for the DABS development program. This description is based on AFC Working Paper No. 42WP-5083 DABS Data Link Applications Formats (Revision 1), 12 Feb. 80 by J.L. Leeper and R.S. Kennedy.

The DAAS system will include the hardware and software to demonstrate the following DABS applications:

1. Minimum Safe Altitude Warning (MSAW) alerts (terminal area)
2. Takeoff Clearance Confirmation
3. Altitude Assignment Clearance Confirmation (Enroute)
4. Weather Requests, Reports
   a) Surface Observations
   b) Terminal Forecasts
   c) Pilot Reports
   d) Winds
   e) Hazardous Weather Advisories
5. ATC Message Acknowledgement

Growth Provisions and hardware compatibility will be provided for:

1. Digitized Weather Radar Maps
2. Downlink of other Comm B Airborne Messages
3. Enhanced Terminal Information Services (ETIS)

Pilot interfaces to the DABS function are through the:

- DABS Light
- Horn
- IDCC Complex

which are indicated on Figure 46.

The DABS light is grouped with the DAAS system warning and caution lights above the EHSI moving map display and to the left of the ADI. This alert is lit whenever a DABS

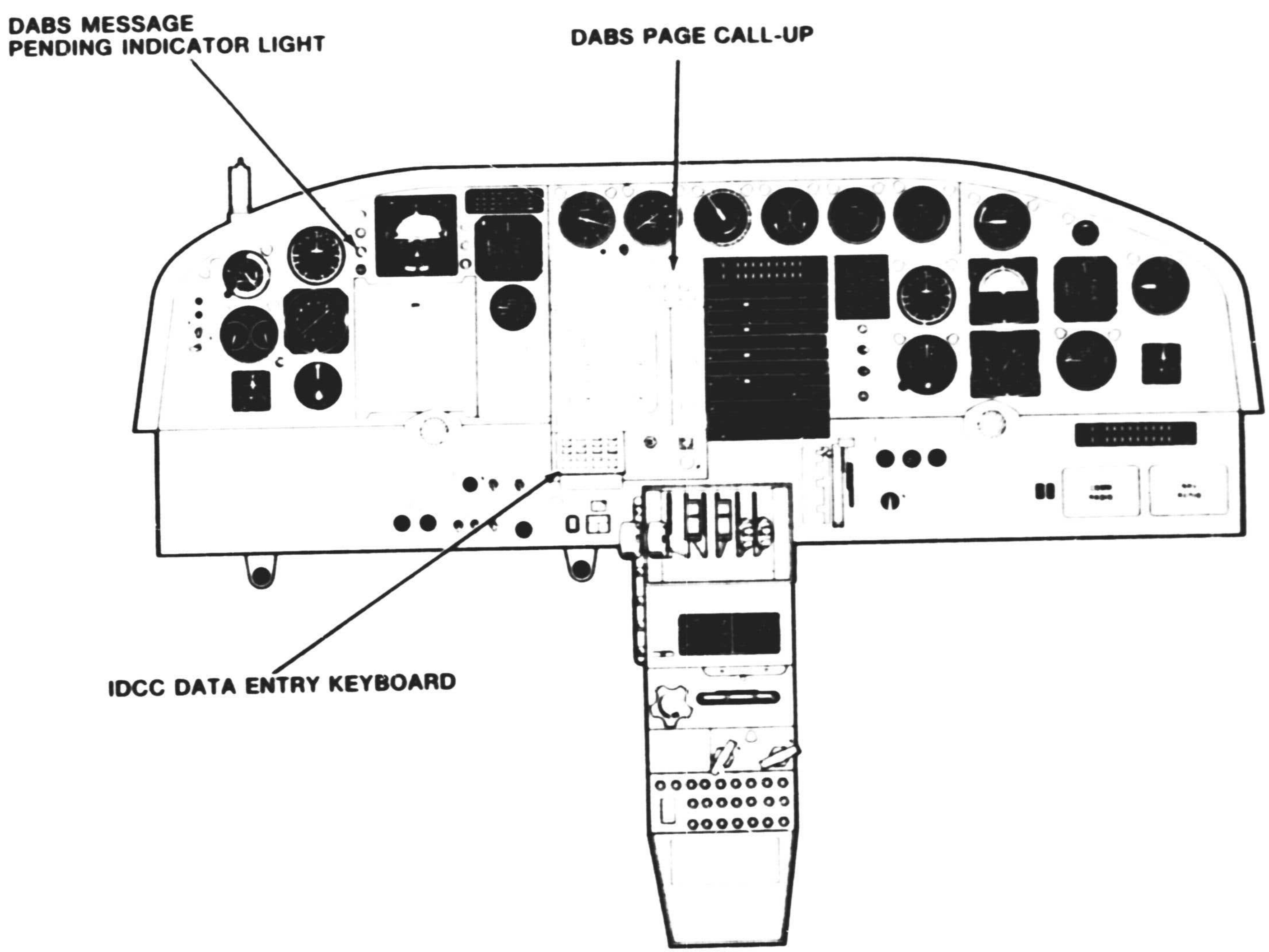


Figure 46. DAAS Panel

uplink message is pending. The horn (not shown) is sounded along with the light if the uplink message is a priority message. The IDCC complex is the pilot's primary interface, with the DABS function. The DABS page select button is used to call up DABS pages on the IDCC CRT. The keyboad is used to enter data.

The pilot responds to a DABS "Message Pending" light by pushing the DABS function button on the IDCC. This action will call up the DABS page. Only one message will be displayed at a time. However, up to five Comm A messages will be queued by the DABS processor. Priority messages will always be moved to the top of the queue. The "Message Pending" light is extinguished when all stored messages have been displayed.

DABS IDCC pages are shown in Figure 47. DABS page 1 displays received messages and provides capability for message acknowledgement and message clear. DABS page 2 is the weather request data input page, and includes capability to command the transmission (SEND) of the weather request message.

The DABS page 1 MSG CLR touchpoint is used to remove a received message from the IDCC display, and allow display of the next pending message. If no additional DABS uplink messages are pending, the message field of the IDCC will go blank and the DABS light will go out. The DABS page 1 MSG ACK touchpoint will send a message acknowledge downlink transaction to the ground station.

Examples of received messages associated with minimum safe altitude warning, takeoff clearance confirmation, and altitude assignment are as follows:

Message Type	Example Message
Minimum Safe Altitude Warning	"MSAW 1500"
Takeoff Clearance Confirmation	"TAKEOFF 27R"
ATC Altitude Assignment	"MNTN 50"
	"CTAM FL230"
	"DTAM 120"

Weather report messages are presented using standard abbreviations.

Input data required for various weather reports is indicated on the IDCC DABS page 2. Three letter location ID (LOC) must be entered for any request. Two-digit GMT at which a forecast is desired must be entered for any request except Surface Observation. Altitude in feet must be entered for Winds Aloft request.

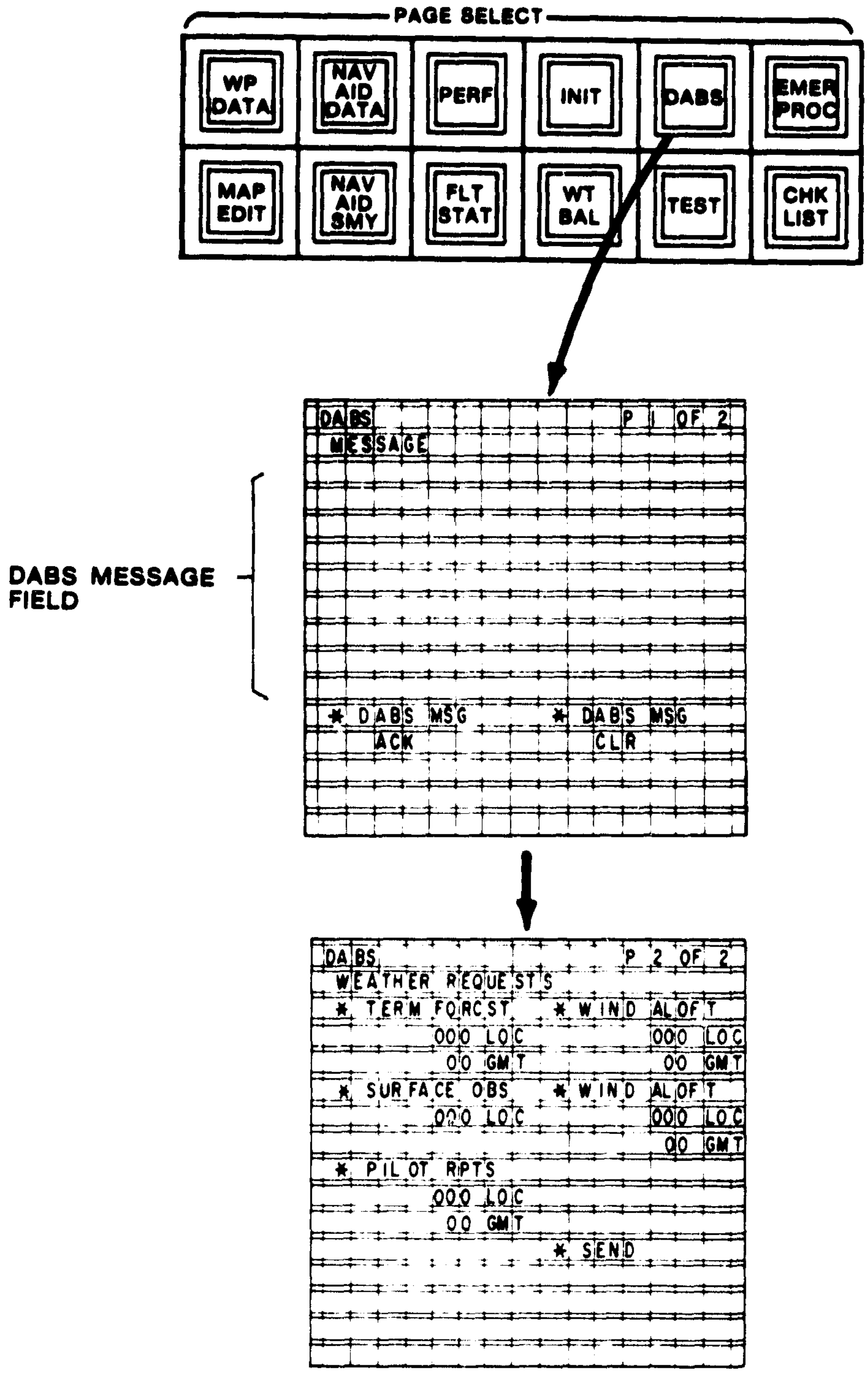


Figure 47. DABS IDCC Display Pages

The SEND touchpoint is used to send a weather request message. The IDCC clear key and enter keys are used along with the alphanumeric keys to enter data onto the pilot request for data page. The SEND command will send weather requests as indicated by a >. The > will point to the last selected touchpoint.

Figure 48 shows the basic DABS information flow in the DAAS system. Uplink and downlink transmissions are sent on dedicated serial busses between the transponder and the DABS processor. This processor formats and controls all DABS information. Uplink messages are sent to the IDCC for display on the 488 system bus. Pilot entered data and responses are returned on the system bus to the DABS processor. Pilot alert signals are also sent by the DABS processor via the system to the Autopilot I/O Processor which controls the lights.

5.10 DAAS Built-In Test (BIT)

The DAAS system includes built-in test (BIT) to assist maintenance and fault isolation. The BIT is designed to facilitate demonstration of avionics testing in the context of projected advanced general aviation maintenance concepts. The ultimate objective of the BIT approach is system fault detection and fault localization to a replaceable unit with confidence over 90 percent without using special test equipment. DAAS includes a sampling of the BIT required to accomplish this objective.

DAAS BIT test modes include:

- In-flight test
- Functional test/fault localization — automatic
- Functional test/fault localization — interactive
- Maintenance troubleshooting

Characteristics of the various modes are summarized in Table 8.

In-flight test is continuous, and will generate a warning when a detected failure will disable a system function. The DAAS will automatically reconfigure for some computer unit processor failures.

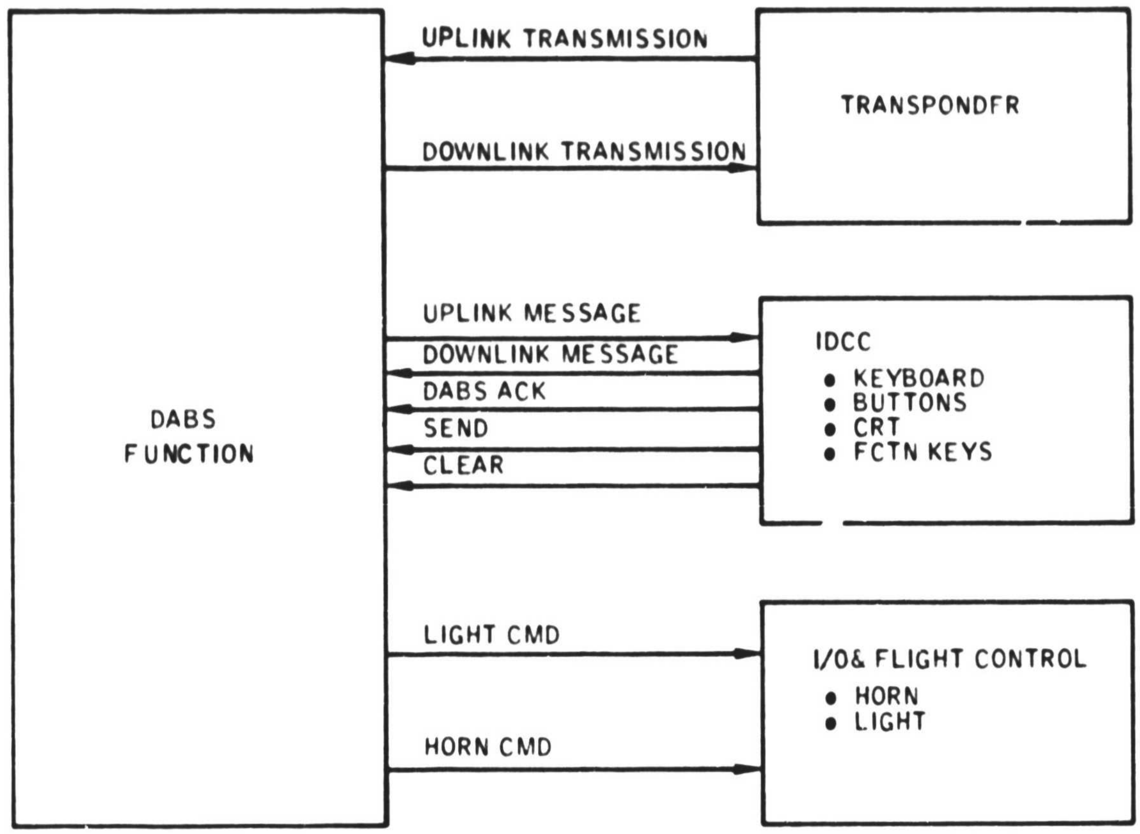


Figure 48. DABS Information Flow

Table 8. DAAS BIT Mechanization

Test Mode	Inputs, Commands	Outputs
IN-FLIGHT TEST	Continuous, no input required	• Warning, Failure Identification • In Flight Failure Data Recording
FUNCTIONAL TEST FAULT LOCALIZATION AUTOMATIC	• Automatic Initiation at Power Up • Test Initiate Commands System Test	• Warning, Failure Identification • Faulty LRU, Faulty Module Identification for Selected Faults
FUNCTIONAL TEST FAULT LOCALIZATION INTERACTIVE	• Test Pattern Command	• IDCC Test Pattern • EHSI Test Pattern
MAINTENANCE TROUBLE SHOOTING • In Flight Failure Data Declaration	• Memory Word Address	• Memory Word Contents Displayed (Sample at 1 Second Interval)
• DC Signal Generation	• DC Signal Address, Magnitude Desired	• DC Voltage Applied on Selected Computer Output
• Discrete Signal Generation	• Discrete Signal Address, State Desired	• State Applied on Selected Discrete Output
• DC Signal Measurement	• Signal Address	• Selected DC Voltage Magnitude Displayed (Sample at 1 second intervals)
• Discrete Signal Measurement	• Signal Address	• Selected Discrete Signal State Displayed (Sample at 1 second intervals)

In-flight failures that are detected by BIT will cause the red or amber warning light to light. A message identifying the fault will be displayed on the IDCC on the line reserved for warning messages. Failure messages are defined in Table 9.

Functional-Test/Fault-Localization-Automatic is performed at power-up or when commanded by the operator and tests system components as feasible without operator interaction. This test function exercises DAAS equipment and identifies failed LRU's as well as failed modules within the LRU as feasible.

The IDCC INIT page is the first page displayed after power-up. Appearance of the INIT page indicates passage of power-up test.

Functional Localization/Interactive Testing is performed on command and allows testing of devices where operator actions or observations are necessary to complete a test. IDCC and EHSI test pattern tests are included in DAAS as examples of avionics interactive testing.

Table 9. DAAS BIT Tests

Test Initiation	BIT Test	AP I/O Proc	Bus Contr	Spare Proc	EHSI Proc	IDCC Proc	NAV Proc	DAAS Proc	RAU Proc	Reconfiguration	Warning Message	Light	Stored Fail Code
Continuous In-Flight	1. Processor Self-Test-Gen	X	X	X		X		X	X	DAAS Shutdown	(IDCC Blanked)	Red	7FFX
Continuous In-Flight	EHSI, NAV Processor Self-Test				X		X			Spare Proc. Activated	Proc Inop (7FFX)	Amber	7FFX
Continuous In-Flight	2. Watch Dog Timer	X								DAAS Shutdown	(IDCC Blanked)	Red	E57X
Continuous In-Flight	3. Power Supply Ref. Tests												
Continuous In-Flight	+5V DC Supply	X								DAAS Shutdown	(IDCC Blanked)	Red	FE7
Continuous In-Flight	+15V DC Supply	X								DAAS Shutdown	(IDCC Blanked)	Red	FD7
Continuous In-Flight	-15V DC Supply	X								DAAS Shutdown	(IDCC Blanked)	Red	FC7
Continuous In-Flight	+21V DC Supply	X								None	Air Data Inop (FB7)	Amber	FB7
Continuous In-Flight	-21V DC Supply	X								None	Air Data Inop (FA7)	Amber	FA7
Continuous In-Flight	+12V DC Supply	X								None	Bubble Mem Inop (EF7)	Amber	EF7
Continuous In-Flight	-12V DC Supply	X								None	Bubble Mem Inop (EE7)	Amber	EE7
Continuous In-Flight	+24V DC Supply	X								None	Batt Inop (ED7)	Red	ED7
Continuous In-Flight	26V AC Supply	X								Autopilot Disengage	DAAS 26VAC Inop (F97)	Red	F97
Continuous In-Flight	4. Processor Valid Bus Test	X	X							DAAS Shutdown	(IDCC Blanked)	Red	E4X
Continuous In-Flight	5. Bus Monitoring	X				X				DAAS Shutdown	(IDCC Blanked)	Red	E3X
Continuous In-Flight	6. Bus Controller Monitoring		X							DAAS Shutdown	(IDCC Blanked)	Red	E38
Continuous In-Flight	7. Bubble Memory Test		X							None	Bubble Mem Inop (FE8)	Amber	FE8
Continuous In-Flight	8. Trim Servo Monitor	X								Autopilot Disengage	Trim Inop (EC7)	Red	EC7
Continuous In-Flight	9. Servo, Flt DR Com Wrap Around												
Continuous In-Flight	Pitch Servo Com	X								Autopilot Disengage	Autopilot Inop (F87)	Red	F87
Continuous In-Flight	Roll Servo Com	X								Autopilot Disengage	Autopilot Inop (F77)	Red	F77
Continuous In-Flight	Yaw Servo Com	X								Autopilot Disengage	Autopilot Inop (F67)	Red	F67
Continuous In-Flight	Pitch Flt Dir Com	X								Autopilot Disengage	Autopilot Inop (F57)	Red	F57
Continuous In-Flight	Roll Flt Dir Com	X								Autopilot Disengage	Autopilot Inop (F47)	Red	F47

Table 9. DAAS BIT Tests (Concluded)

Test Initiation	BIT Test	API/O Proc	Bus Contr	Spare Proc	EHSI Proc	IDCC Proc	NAV Proc	DAAS Proc	RAV Proc	Reconfiguration	Warning Message	Light	Stored Fail Code
Continuous In-Flight	10. Data Valid Tests												
	VG Valid Discrete (VJ 208)	X								Autopilot Disengage	VG Inop (EB7)	Red	EB7
Continuous In-Flight	Alt Valid Discrete (Rt 221)	X								None	Radar Alt Inop (EA7)	Amber	EA7
Continuous In-Flight	Alt Valid Discrete (KDC 380)	X								Alt Mode Disengage	Alt Inop (E97)	Amber	E97
Continuous In-Flight	IAS Valid Discrete (KDC 380)	X								None	IAS Inop (E87)	Amber	E87
Continuous In-Flight	Gyro Valid Discrete (KSG 105)	X								Autopilot Wings Level Mode	Dir Gyro Inop (E77)	Amber	E77
Continuous In-Flight	Baro Alt Valid Discrete (28702)	X								Alt Mode Disengage	Baro Alt Inop (E67)	Amber	E67
Continuous In-Flight	11. Bus Hardware Test	X	X	X	X	X	X	X	X	DAAS Shutdown	(IDCC Blanked)	Red	E2X
Power Up	1. Processor Self-Test	X	X	X	X	X	X	X		DAAS Shutdown	(IDCC Blanked)	Red	7FFX
Power Up	2. RAM Memory Tests	X	X	X	X	X	X	X		DAAS Shutdown	(IDCC Blanked)	Red	BFFX
Power Up	3. Memory Load Sum Check	X	X	X	X	X	X	X		DAAS Shutdown	(IDCC Blanked)	Red	DFFX
Power Up	4. Watch Dog Timer Hdwe Test	X				X				DAAS Shutdown	DAAS Fcts Fail (EFFX)	Red	EFFX
Power Up	5. Real Time Clock Hdwe Test		X							DAAS Shutdown	(IDCC Blanked)	Red	FB0
Power Up	6. G-Dump Test	X								DAAS Shutdown	(IDCC Blanked)	Red	E17
System Test Com	1. Discrete Wrap Around Test	X								Autopilot Disengage	Autopilot Inop (F37)	Red	F37
System Test Com	2. Analog Wrap Around Test	X								Autopilot Disengage	Autopilot Inop (F27)	Red	F27
System Test Com	3. Servo Test	X								Autopilot Disengage	Autopilot Inop (F17)	Red	F17
System Test Com	4. Radar Altimeter Test	X								None	Radar Alt Inop (F07)	Amber	F07
EHSI Test Com	1. EHSI Test Pattern				X					None	None	None	-
IDCC Test Com	1. IDCC Test Pattern					X				None	None	None	-
Bubble Mem Update	1. Bubble Memory Load Sum Check		X							Utility Only	(IDCC Blanked)	Red	FB8
KCI 310 Test Com	1. KCI 310 Tests	X								None	None	None	-
Maintenance Test Com	1. Stimulate and Measure Tests	X								-	-	-	-
Maintenance Test Com	2. Memory Access	X	X	X	X	X	X	X		-	-	-	-
Continuous	3. Failure Recording		X							-	-	-	-

Maintenance Troubleshooting allows the operator to apply signals and measure signals via IDCC with equipment installed in the aircraft without test equipment. Memory words can be displayed. Analog and discrete signals can be applied at computer outputs, and various system analog and discrete signals can be measured and displayed.

5.10.1 BIT Controls and Displays

BIT IDCC display pages are shown in Figure 49. TEST page 1 allows command of system test, EHSI, or IDCC test pattern or selection of signal generate/measure or memory monitor pages.

EHSI and IDCC test patterns are checkerboards which allow evaluation of display linearity.

Signal generate and measure is performed in the Autopilot I/O Processor. The IDCC buffers the data and sends it to the Auotpilot I/O Processor where the commanded signals are applied if the aircraft has weight-on-wheels and the SIG GEN/MEASURE page is displayed. The signal address is the least significant bit in the I/O address.

Memory monitoring is performed on the MEMORY MONITOR page. Processor ID and memory location are entered as hexadecimal numbers. Continuous or frozen display modes can be selected. Memory readout is also in hexadecimal. Stored fault history data can be cleared using the FAULT MONITOR function. The stored data can be cleared using the FAULT MEM CLEAR function.

The KCI 310 FDI test is commanded by the test button on the FDI.

5.10.2 BIT Mechanization

DAAS BIT tests are listed in Table 9.

Shown are the CPUs that perform the tests, the test mode that activates the tests, and the safety interlocks to prevent the tests during unsafe conditions. In flight, ten tests are active. These are:

1. Processor Self-test Sample Problem — A short sample problem is performed in each processor to test its operation.

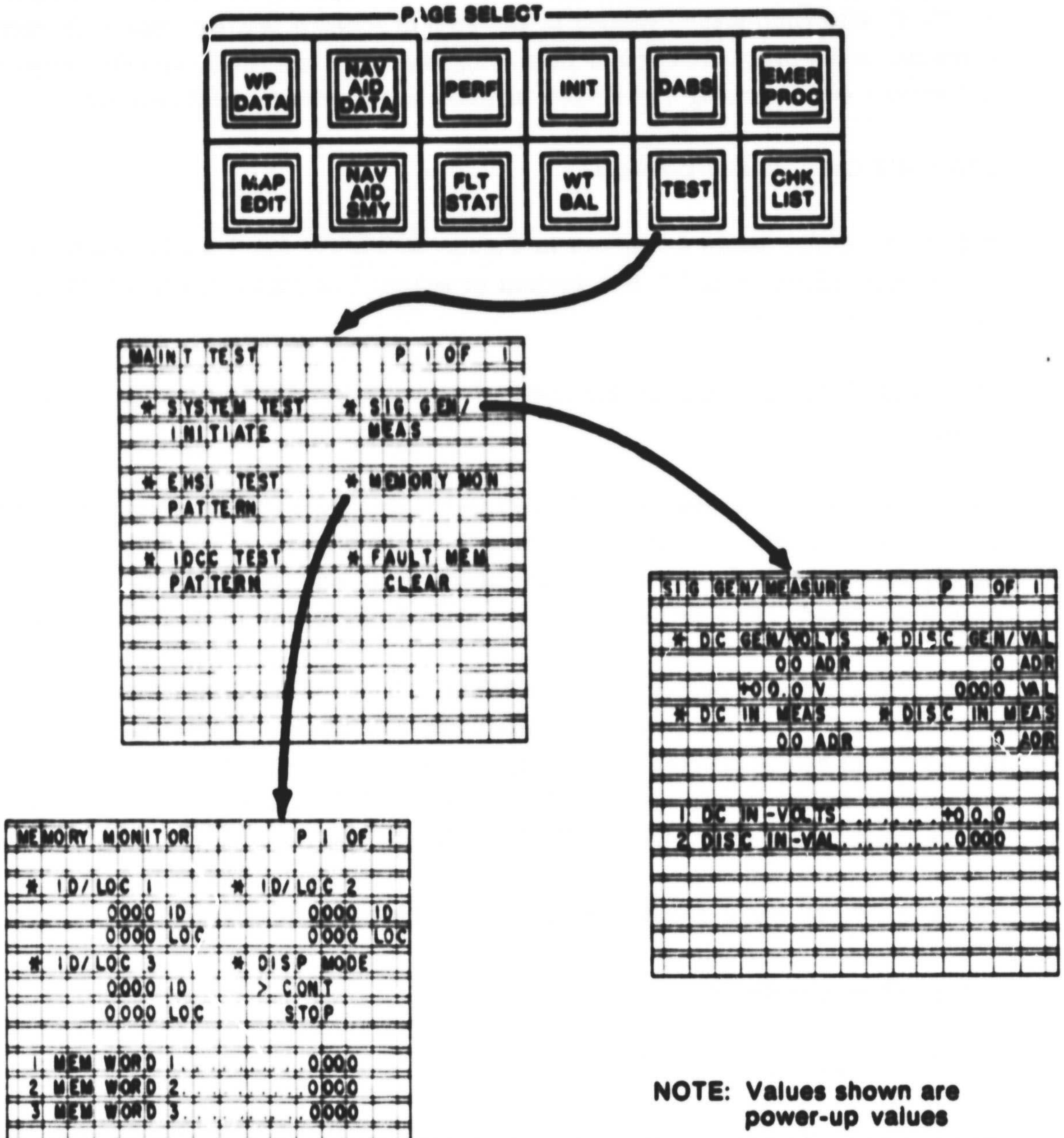


Figure 49. BIT IDCC Display Pages

2. Watchdog Timer — The Autopilot I/O Processor and IDCC watchdog timers are tested to make sure that neither has timed out. If the IDCC watch dog timer times out, the IDCC screen goes blank.

3. Power Supplies — The power supplies are tested for proper outputs.

4. Processor Valid Bus Test — The Bus Controller and the Autopilot I/O Processors monitor the valid words sent from each processor. These processors store failure indications and print warning measures for system failures.

5. Bus Monitoring — The Autopilot I/O Processor and the IDCC test for periodic transmission from the bus controller to detect a dead bus. A test for transmission of all 1s is also performed.

6. Watchdog Timer of Bus Control Algorithm -- The bus controller tests itself via the real-time clock interrupt for proper sequencing through its program.

7. Bubble Memory Test — The status register from the bubble memory is tested for proper status.

8. Pitch Trim Monitor — The pitch trim monitor checks the pitch trim for a run away condition.

   The trim system is monitored by comparing the trim motor command and the sense of the trim motor operation. A failure is declared if

   a. the motor runs with no command.
   b. the motor runs in the opposite direction from the command.
   c. there is a trim command but the motor fails to run after 10-second delay.

   The manual electric trim action is monitored in the same fashion by comparing the command with the resulting motor response.

9. Servo Command Wraparound — The servo commands are tested via wrap-arounds for proper commands.

10. Data Valid Tests — The valid discretes from the vertical gyro, radar altimeter, altimeter, airspeed sensor, and directional gyro are tested.

11. Bus Hardware Test — Check to see that IEEE 488 bus drivers are capable of outputting 1s and 0s.

Tests automatically initiated at power up consist of the following:

1. Processor self-test
2. Memory Test — Prior to loading from the bubble memory, each processor tests its RAM memory.
3. Sum Check — After loading from the bubble memory, each memory is sum checked to verify the load.
4. WDT Hardware Tests — The Autopilot I/O Processor and IDCC Processor check their watchdog timer circuitry.
5. Real Time Clock Hardware Test — Check for running clock.
6. G-Dump Test — G-Dump circuitry is tested.

Four tests are performed in the Autopilot I/O Processor when system test is commanded.

1. Discrete Wraparound Tests — The Autopilot I/O Processor tests the discrete wraparounds for both states.
2. Analog Wraparound Tests — Analog outputs and inputs are tested via wraparound tests.
3. Servo Monitors — The servo amps are tested for proper operation.
4. Radar Altimeter Test — The altimeter is tested for nominal output by commanding it into test mode and measuring the test output.

The operation of both the IDCC and EHSI are also tested on command. These tests check the CRT memories as well as displaying a test pattern. Additional tests include a sum check when loading the bubble memory, KCI 310 tests, signal generate and measure tests, and memory access testing.

BIT hardware logic is illustrated in Figure 50. Hardware logic is included to control:

- Red warning light operation
- Yaw damper and autopilot engagement enable
- Autopilot clutch engagement enable
- IDCC blanking

The DAAS warning light, yaw damper enable, autopilot enable, and autopilot clutch enable will be activated by the autopilot I/O processor for detected processor faults. The autopilot I/O processor watch dog timer (WDT) will time out for an autopilot I/O processor failure and will light the red warning light, disengage the yaw damper and autopilot clutch, and blank the IDCC. A normal acceleration greater than 1-g (g-DUMP) will also disengage the autopilot.

The IDCC processor will command the display to be blanked for a detected processor or bus fault. The IDCC WDT and the autopilot I/O processor WDT also blank the display for detected processor or bus faults. The IDCC is blanked for failed autopilot I/O processor because the IDCC is not trustworthy with faulty system I/O.

DAAS includes capability to induce two representative failures for demonstration purposes. Failure command switches cause:

1. Total computer failure (system master clear), or
2. EHSI processor failure.

5.11 CHECKLISTS, EMERGENCY PROCEDURES

Stored Cessna 402B checklists and emergency procedures are shown in Figure 51 and 52, respectively. The IDCC page back/advance control can be used to step from checklist to checklist. The checklist or procedure item arrow can be advanced by hitting the ENTR button. The arrow cannot be backspaced.

The engine-out takeoff emergency procedure is the only one implemented for demonstration purposes.

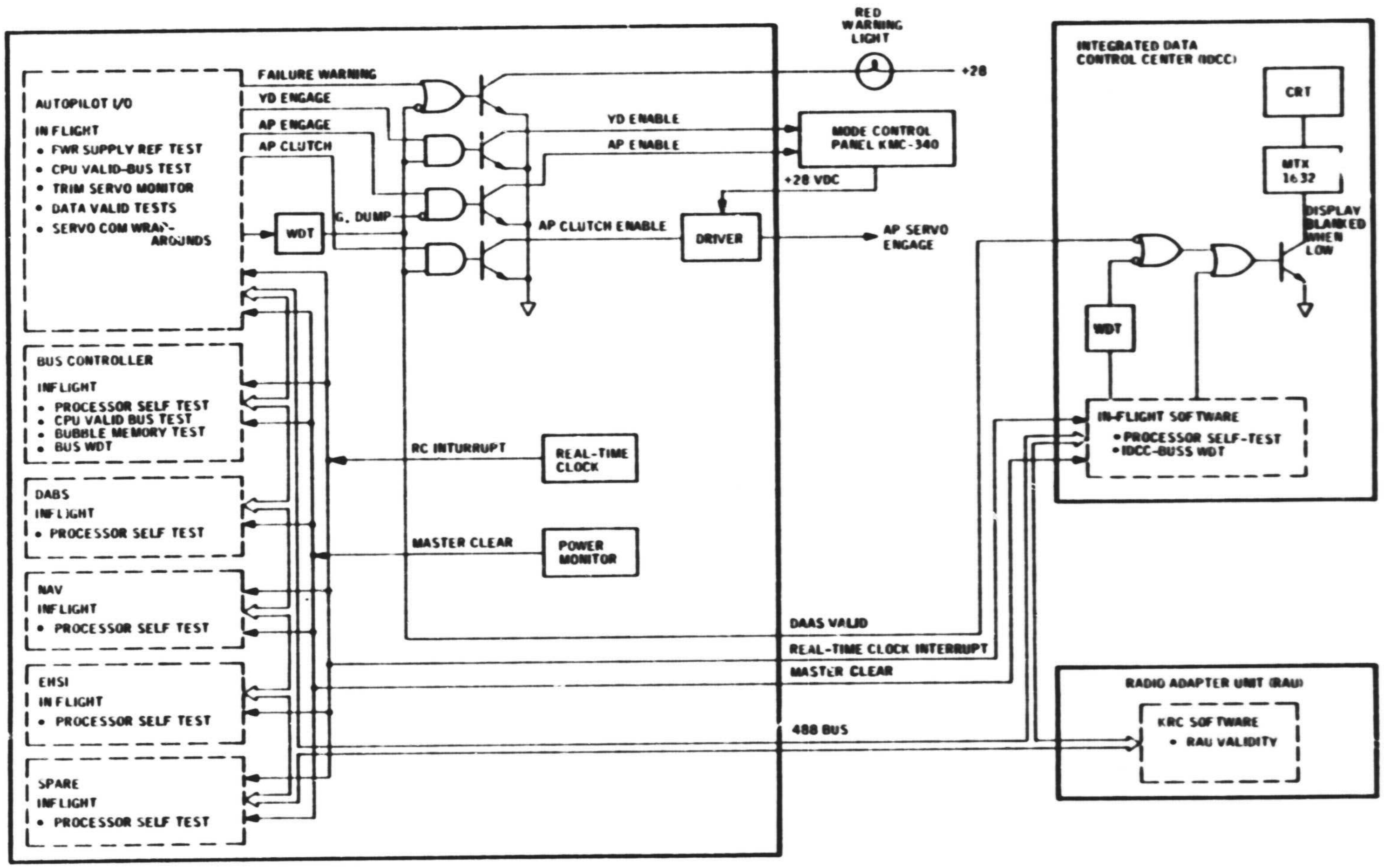
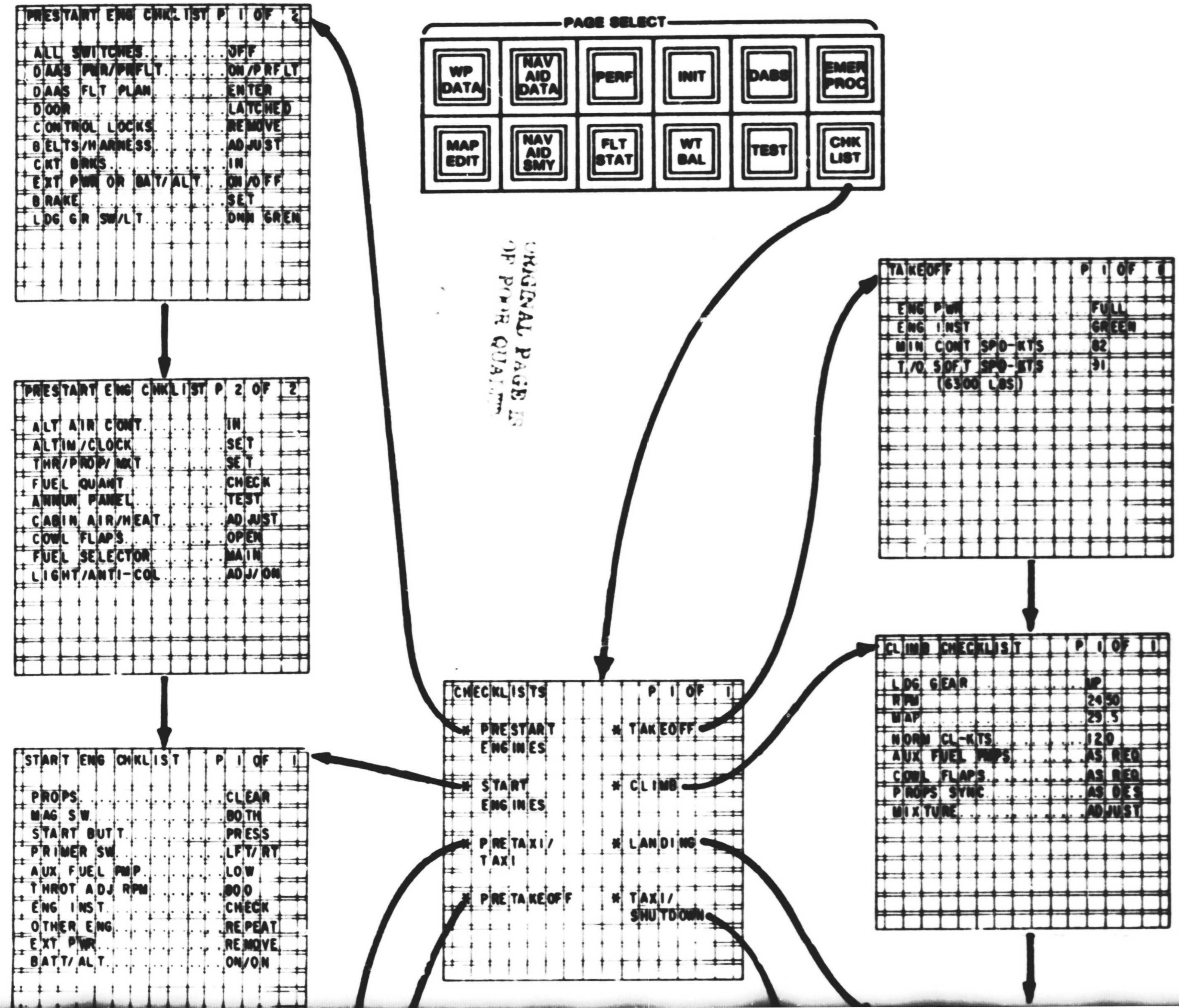


Figure 50. DAAS BITE Hardware Logic



FOLDOUT FRAME

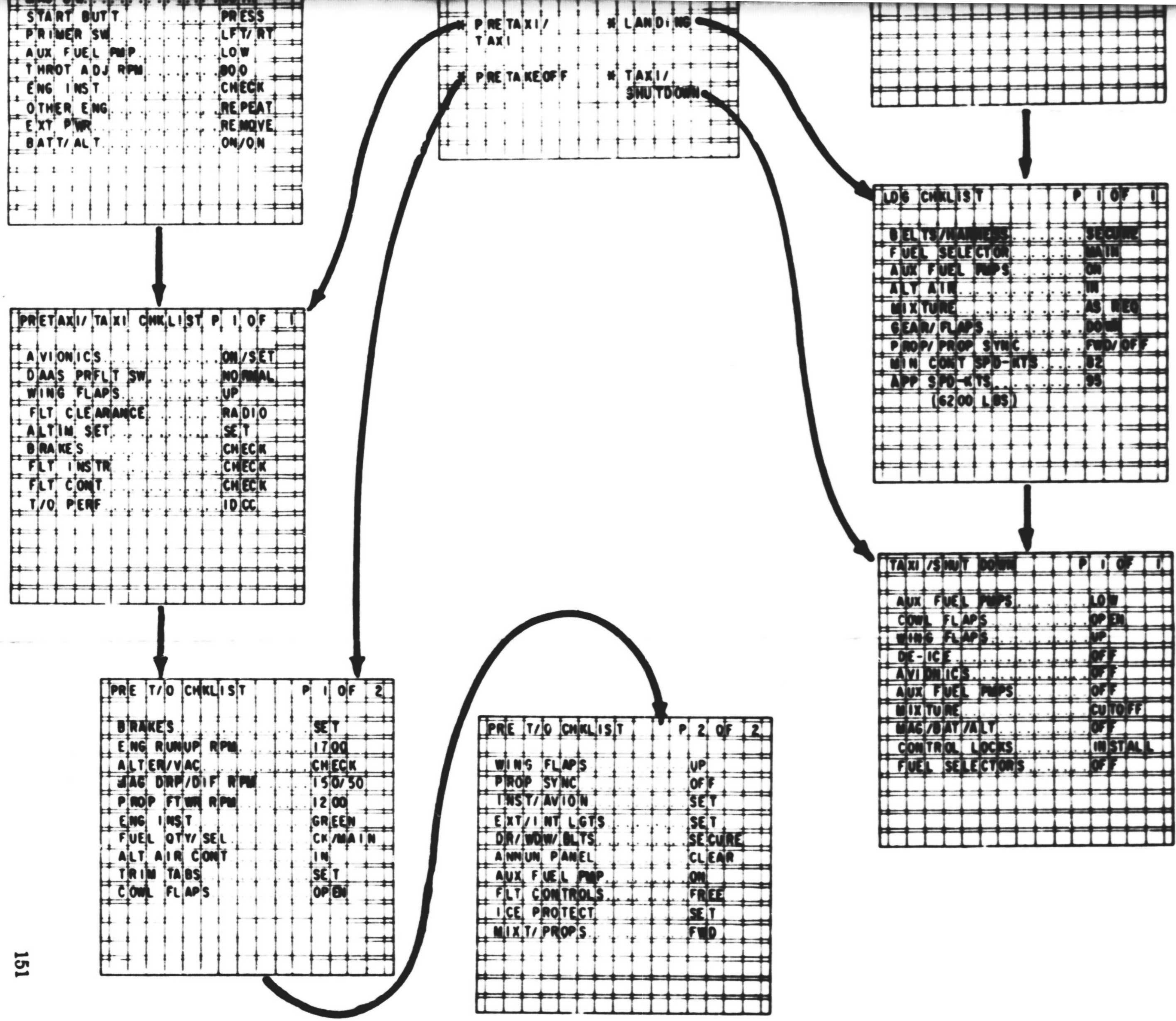


Figure 51. IDCC Check List

FOLDOUT FRAME 2

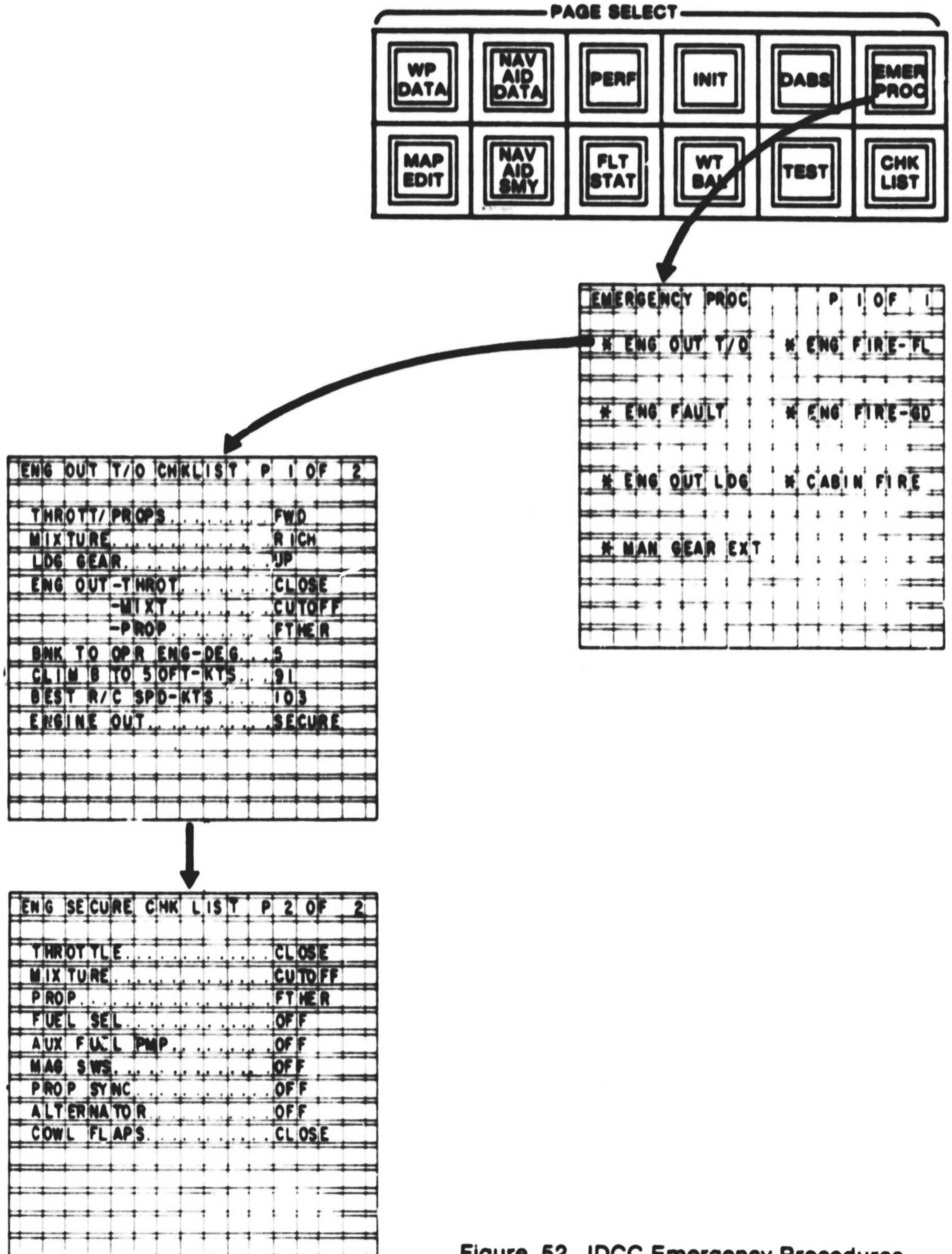


Figure 52. IDCC Emergency Procedures

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Section 6.0
Safety Pilot Instrument Panel

The right side cockpit panel (Figure 53) has all the instruments required for IFR flight. The attitude instrument is a KG 258 air driven artificial horizon. The KG 258 can provide the pilot with information to control the aircraft attitude in the unlikely event of a total electrical failure. The horizontal situation indicator is a KI 525A which is driven by a King KCS 55A Compass System and Navigation Receiver which are part of the Cessna 402B current equipment. The standard aircraft engine instruments are arranged for convenient use by both left and right seat pilots. The fuel flow instrument is the type used on the 402C.

The safety pilot panel provides IFR flight capability if the DAAS should not be installed in the aircraft or if the DAAS should fail and become inoperable.

A navigation radio and a communication transceiver are located on the lower right side of the instrument panel. These radios are independent of DAAS and are for the use of the safety pilot. The navigation receiver is connected to the KG525 Pictorial Navigation Indicator on the safety pilot side. The KMA24 Audio Control Panel allows the safety pilot to monitor all radios, including the DAAS radios, and to transmit on either the DAAS KY196 Transceivers or the safety pilot's communication transceiver.

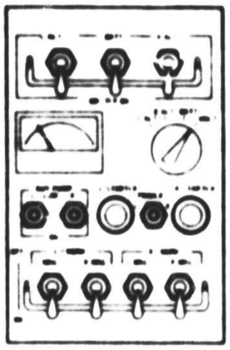
The DMA receiver can be used by the safety pilot by placing the switch on the front of the DME in the "FREQ" position for tuning, and then in the "GS/T" position to read the distance to the station, ground speed toward the station, and the time to station.

The DAAS navigation radios may also be tuned by the safety pilot, but the only navigation indicator, driven by the DAAS radios, independent of the DAAS computer is the KI226 located at the left side of the panel. For safety pilot use, the navigation receivers must be placed in the manual tuning mode using the switches to the right of the radios. The proper radio (NAV1 or NAV2) must also be selected with the switch located at the lower left of the KI226 RMI. If desired, the DME may be channeled from the navigation receivers by selecting the proper NAV receiver (1 or 2) on the switch to the right of the DME receiver. The switch on the front of the DME must be in the remote (RMT) position for channeling from the NAV receiver. The KY76A Transponder is independent of DAAS and can be operated by either pilot.

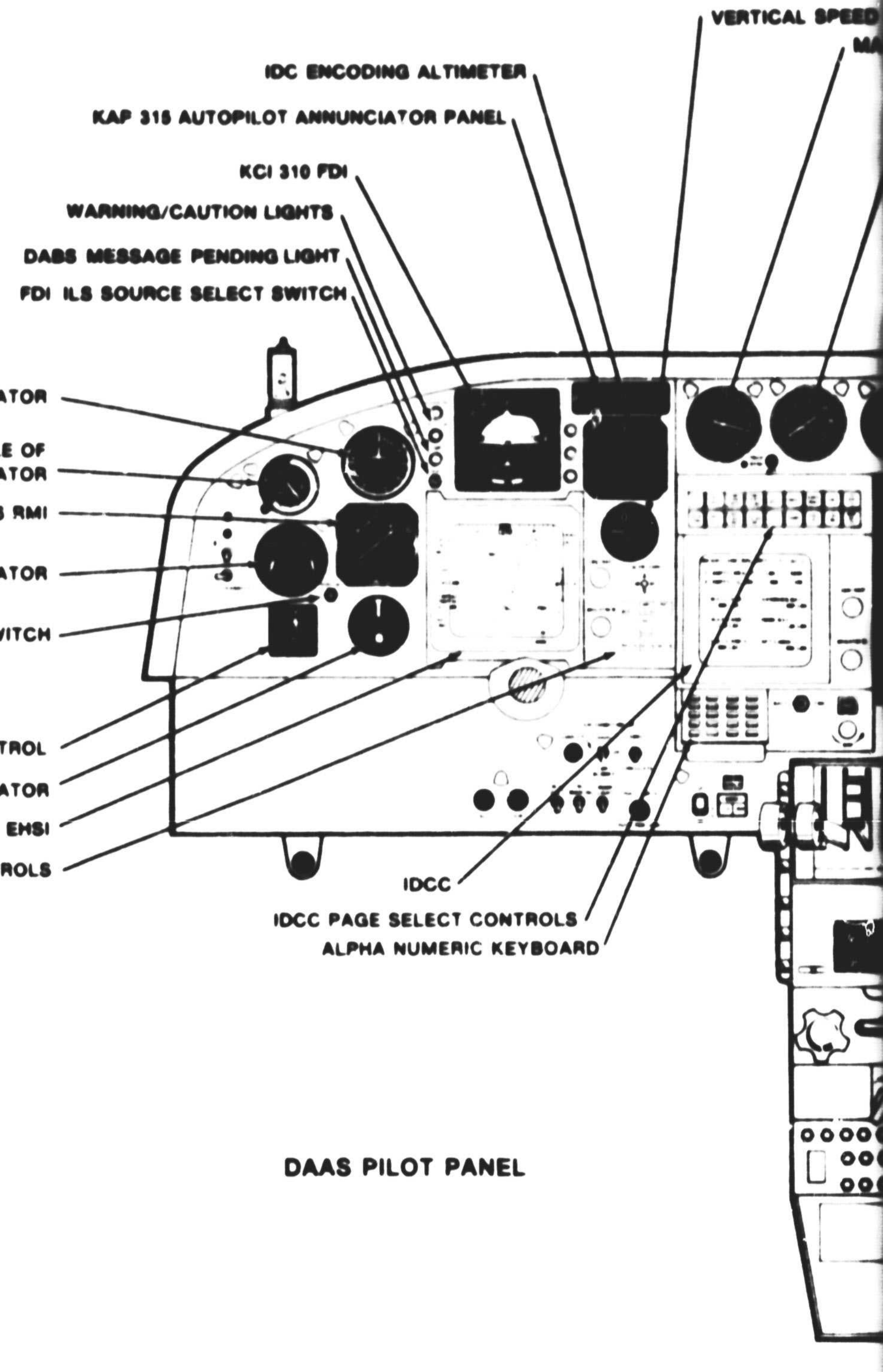
Engine starting, battery, fuel boost pumps, and magnetic switches are located on a center overhead panel as shown in Figure 53. This provides the safety pilot with access to the switches necessary for engine starting and engine shutdown.

A circuit breaker panel located in the center lower pedestal provides the pilots with a means of disconnecting DAAS functions. If the upper left circuit breaker is pulled (CBD 01), the computer is disconnected and the servos are disengaged. See Figure 53 for panel location.

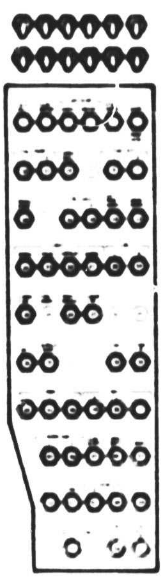
The safety pilot panel, including central instruments and controls, thus provides complete facilities for IFR flight independent of the DAAS system.



OVERHEAD CONTROL PANEL



DAAS PILOT PANEL



LEFT CIRCUIT BREAKER PANEL

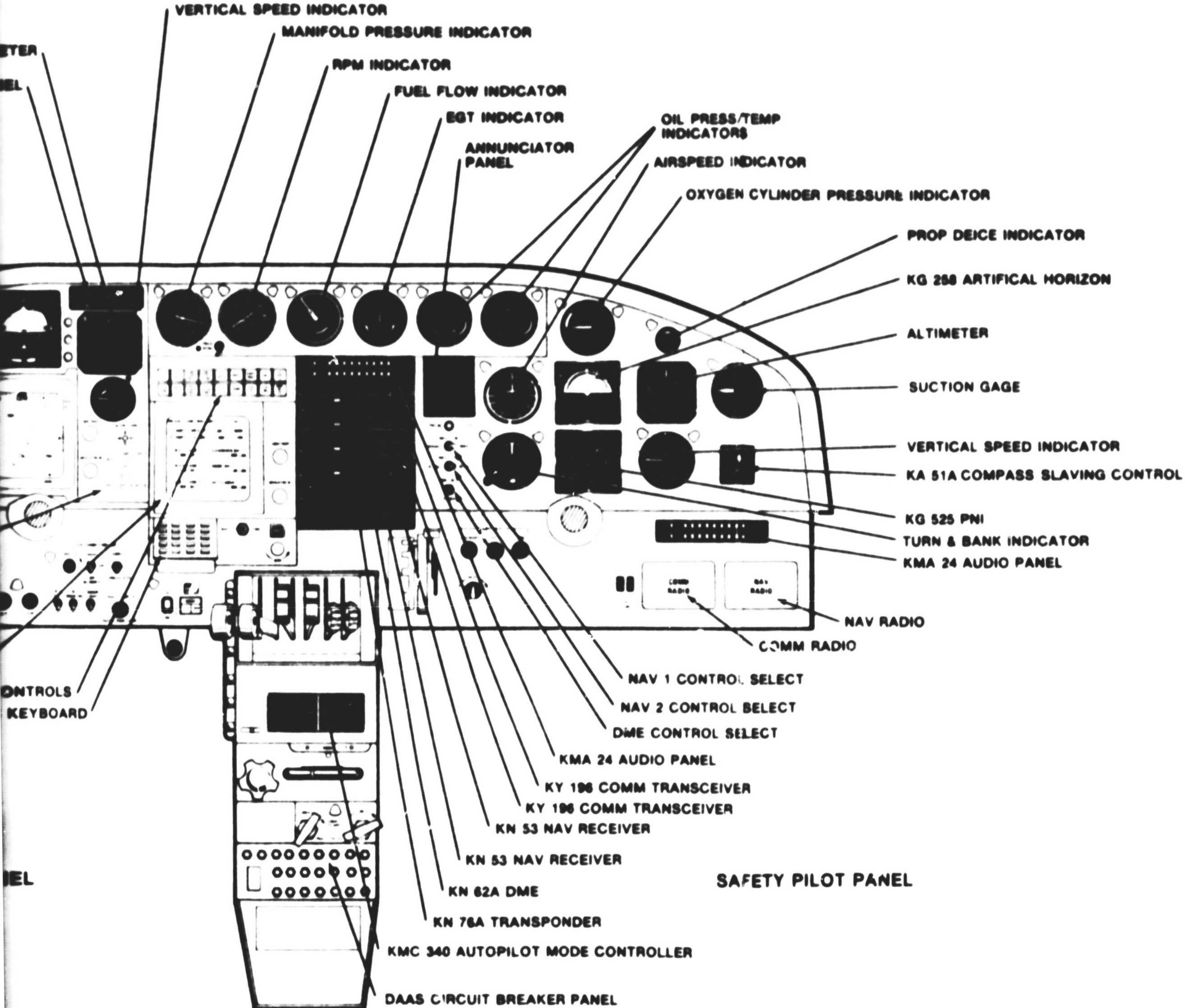


Figure 53. DAAS Control Panel

FOLDOUT FRAME 2

Section 7.0
DAAS System Interface

The DAAS system block diagram is shown in Figures 2 and 3. The interfaces connecting the system elements are as follows:

- Computer I/O
- Computer/IDCC interface
- Computer/EHSI interface
- Computer/RAU interface

7.1 COMPUTER I/O

The computer I/0 is the system interfacing with the aircraft. It includes all aircraft sensor inputs and command outputs. It consists of analog inputs, analog outputs, discrete inputs, and discrete outputs. All inputs and outputs are memory mapped. Table 10 shows the analog inputs along with the sensor output scaling, prefilter characteristics, and prefilter output scaling. There are 64 analog inputs, including 13 spares. Table 11 shows the analog outputs together with the sample and hold output scaling and the computer box output scaling where applicable. A total of 16 outputs are provided. Table 12 lists the discrete inputs and outputs. As shown there are 48 discrete outputs including nine spares and 48 discrete inputs including two spares. Both the discrete inputs and outputs are implemented as bit packed words. The inputs are implemented with four words and use 12 bits of each word. The outputs are implemented with three words that use 16 bits each. The complement of the output of word 1 is "wrapped around" to input word 4 for monitoring purposes.

7.2 COMPUTER/IDCC INTERFACE

The computer/IDCC interface is accomplished over the IEEE 488 bus. This bus is a 16-wire, 8-bit parallel bus. The data transmitted over this bus includes keyboard output data, IDCC messages, EHSI display related information, etc. Table 13 shows the definition of the various data buffer contents that are transmitted over the bus.

Table 10. Analog Inputs

Signal Designation	Analog Input Ref No.	Sensor Output	Prefilter Gain	Prefilter τ (sec)	Prefilter Output	Sensor Full Scale	Full Scale On A/C	Full Scale At A/D	Address Hex	
MAP (Port) #1	1	3.68mV/in Hg	66.56	0.02	0.245V/in Hg	60 in Hg	34.5 in Hg	8.45V	[illegible]	
MAP (Stbd) #2	2	3.68mV/in Hg	66.56	0.02	0.245V/in Hg	60 in Hg	34.5 in Hg	8.45V	[illegible]	
Fuel Flow (Port) #1	3	0.025V/PPH	1	0.02	0.025V/PPH	250 PPH	191 PPH	4.8V	[illegible]	
Fuel Flow (Stbd) #2	4	0.025V/PPH	1	0.02	0.025V/PPH	200 PPH	191 PPH	4.8V	[illegible]	
Yaw Rate	5	0.2V/°/sec	2.5	0.02	0.5V/°/sec	20°/sec	20°/sec	10V	[illegible]	+ Yaw left
Radar Alt	6	-4mV/ft	-1	0.02	4mV/ft	2500 ft	--	10V	[illegible]	
Baro Alt	7	V 0.025/kft	0.667	0.02	V 0.0167/kft				[illegible]	V = 15V nom, 0ft = 0.05V nom
Δ B+ Ref	8	24 Vdc	0.399	0.02	- 9.58	--	--		00870	
Δ VFUP	9	$\frac{(0.875-0.75a)B^{+}}{1+15}$	0.458	0.02				a=0 a=1 9.62 - 1.37	[illegible]	
Pitch Trim Adj	10	± 15Vdc	0.667	0.02	± 10V	--	--	± 10V	[illegible]	
Roll Trim Adj	11	± 15Vdc	0.667	0.02	± 10V	--	--	± 10V	00830	
Yaw Trim Adj	12	± 15Vdc	0.667	0.02	± 10V	--	--	± 10V	00832	
OAT	13	6.36mV/°C	15.740	0.02	0.1V/°V	± 100°C	--	± 10V	[illegible]	
Pitch (Gyro)	14	206mV/°	0.987Vdc/Vac	2nd order	203mV/°		57.9°	± 10V	[illegible]	Up +
Roll (Gyro)	15	206mV/°	0.987Vdc/Vac	2nd order	203mV/°		57.9°	± 10V	[illegible]	Rt +
RPM (Port)	16	1.67mV/rpm	1	0.02	1.67mV/RPM	--	2700 rpm	4.5V	[illegible]	
RPM (Stbd)	17	1.67mV/rpm	1	0.02	1.67mV/RPM	--	2700 rpm	4.5V	[illegible]	
Hdg Sel Slew	18	± 4.25 ± 0.5Vdc	0.667	0.02	±2.83 ± 0.33Vdc		--	± 10V	[illegible]	Rt + (CW)
Vert Trim	19	± 15Vdc	0.667	0.02	± 10V	--	--	± 10V	[illegible]	Discrete +15° 0° 15V + Up
Hdg (Sin)	20	11.8V Synchro	--	0.02	0.485 Sin θ	--	--	0.485V	[illegible]	
Hdg (Cos)	21	11.8V Synchro	--	0.02	0.485 Cos θ	--	--	0.485V	[illegible]	
Cowl Flap (Port)	22		0.667	0.02					[illegible]	
Cowl Flap (Stbd)	23		0.667	0.02					[illegible]	
Pitch Servo f.b.	24	0.19V/°/s	1	0.02	0.19V/°/s				00810	
Roll Servo f.b.	25	0.046V/°/s	1	0.02	0.046V/°/s				00812	
Yaw Servo f.b.	26	0.061V/°/s	1	0.02	0.061V/°/s				00822	
Δh (380)	27	25mV/ft	1	0.02	25mV/ft	± 600ft		± 400ft	[illegible]	+ 15V max + above
ḣ	28	60mV/ft/s	1	0.02	60mV/ft/s	± 250ft/s		± 166ft/s	[illegible]	
IAS	29	+75mV/kt -18.75V	0.667	0.02	50mV/kt -12.5V			50 - 450kt	[illegible]	0V = 250kt -10V = 50kt
Elev. Trim	30	8.38/11.76	0.667	0.02	5.59/7.84				[illegible]	To range
Flt Test Spare 1	31	± 15V	0.667	0.02	± 10V	--	--	± 10V	[illegible]	
Flt Test Spare 2	32	± 15V	0.667	0.02	± 10V	--	--	± 10V	[illegible]	
TAS	33	45Hz/kt	0.889mV/Hz	0.02	0.04V/kt	250kt	250kt	10V	[illegible]	

Table 10. Analog Inputs (Concluded)

Signal Designation	Analog Input Ref No.	Sensor Output	Prefilter Gain	Prefilter τ (sec)	Prefilter Output	Sensor Full Scale	Full Scale @ A/C	Full Scale At A/D	Address Hex	
+5V DC	34	1 V/V	1	0.02	5Vdc				0061F	5.0V nom
25VAC Mon	35	1 V/V	0.270Vdc/Vac	0.02	0.270Vdc/Vac			10 VDC 37 VAC	0062E	7.031 nom
Flap Pos (Right)	36	5.55V-0.0523 (Flap)	1	0.02	5.55V-0.0523 (Flap)V				00624	
Pitch Cmd Bar WA	37	0.667V/°	1	0.02	0.667V/°	±10V			00650	
Roll Cmd Bar WA	38	0.5V/°	1	0.02	0.5V/°	±10V			00652	
VNAV Dev. WA	39	1.5mV/ft	13.32V/V	0.02	20mV/ft	500ft		10V	00672	
Pitch Servo Cmd WA	40	5.0V/°/s	1	0.02	5.0V/°/s	±10V		±10V	00614	
Roll Servo Cmd WA	41	3.33V/°/s	1	0.02	3.33V/°/s	±10V		±10V	00616	
Yaw Servo Cmd WA	42	2.0V/°/s	1	0.02	2.0V/°/s	±10V		±10V	00620	
Spare Output WA #1 (BIT)	43	±10V	1	0.02	±10V	±10V		±10V	0062A	
Spare Output WA #2	44	±10V	1	0.02	±10V	±10V			00674	
+15VDC	45	1 V/V	0.5	0.02	0.5V/V				0063E	+7.55 nom
-15VDC	46	1 V/V	0.5	0.02	0.5V/V				0065E	-7.55 nom
+21VDC	47	1 V/V	0.249	0.02	0.249V/V				0061C	+5.23 nom
-21VDC	48	1 V/V	0.249	0.02	0.249V/V				0063C	-5.23 nom
+28VDC	49	1 V/V	0.249	0.02	0.249V/V				0067E	6.97 nom
+12VDC	50	1 V/V	0.5	0.02	0.5V/V				0065C	+6.0 nom
-12VDC	51	1 V/V	0.5	0.02	0.5V/V				0067C	-6.0 nom
Spare	52								00654	
Spare	53								00656	
Spare	54								00658	
Spare	55								0065A	
Spare	56								00676	
Spare	57								00678	
Spare	58								0067A	
Spare	59								00610	
Spare	60								00614	
Spare	61								00634	
Spare	62								00636	
Spare	63								00630	
Spare	64								0063A	

Table 11. Analog Outputs

Signal Designation	Output at S&H	Output at Comp. Box	Address Hex
Pitch Servo Cmd	5.0 V/°/s (+Up)		08000
Roll Servo Cmd	3.33 V/°/s (+Rt)		08002
Yaw Servo Cmd	2.0 V/°/s (+Rt)		08004
Pitch Cmd Bar	.667 V/°-(Up)	1.0 V/°	08006
Roll Cmd Bar	.50 V/° -(Rt)	0.75 V/°	08008
VNAV Dev	20 mV/ft -(Above)	0.30 μA/ft	0800A
Spare Output #1			0800C
Spare Output #2			0800E
Rec. Ch 1			08010
Rec. Ch 2			08012
Rec. Ch 3			08014
Rec. Ch 4			08016
Rec. Ch 5			08018
Rec. Ch 6			0801A
Rec. Ch 7			0801C
Rec. Ch 8			0801E

7.3 COMPUTER/EHSI INTERFACE

The computer/EHSI interface consists of a coaxial video cable. The video information for the EHSI display is generated in the EHSI refresh memory which is located in the computer box. This video information is transmitted over the coax cable to the EHSI. The coax has an impedance of 75 ohms.

7.4 COMPUTER/RAU INTERFACE

The computer/RAU interface is accomplished over the IEEE 488 bus. Refer to Table 13 for the definition of the data transmitted over the bus.

Table 12. Discrete Inputs and Outputs

BIT	Input Word 1 08800	Input Word 2 08802	Input Word 3 08804	Input Word 4 08806	Complement	Output Word 1 08200	Output Word 2 08202	Output Word 3 08204
15	HDGSSLW (1=on)	APENG (1=eng)	AUXPMP 1 (1=on)	APCLENG		APCLENG	NAV ARM	MSTR WRN
14	HDG SEL (1=on)	YDENG (1=eng)	AUXPMP 2 (1=on)	AP SOL		AP SOL	NAVCPLD	MSTR CTN
13	APPR (1=on)	APYDDC (1=disc)	DROPEN (0=open)	YD SOL		YD SOL	REV LOCA	TRM FAIL
12	NAV (1=on)	FLT DIR (1=on)	WOW (0=wow)	ALT ENG		ALT ENG	YAW DMPA	ALTALRT
11	VNAV (1=on)	MNTRM (1=on)	GR DN LK (0=down)	VNAVSHTR		VNAVSHTR	HDGSELA	DH ANN
10	ALT (1=on)	FLTT 1 (1=on)	VG VAL (1=val)	CMDBRRET		CMD BR RET	VNAVARMA	MDA ANN
9	ALT ARM (1=on)	TRMPWR (1=on)	DG VAL (1=val)	REV LOC		REV LOC	VNAVCPLDA	DABS ANN
8	SYSINTLK (0=inter-lock)	TRM UP M (1=on)	BALT VAL (0=val)	ATRM UP		ATRM UP	GS CPLD A	PTRMTST
7	G DUMP (0=dump)	TRM DN M (1=on)	FLT T 2 (1=on)	ATRM DN		ATRM DN	ALTARMA	R ALT TST
6	CWS (0=on)	PATL UP (0=up lim)	IAS VAL (0=val)	CMPTRVAL		CMPTRVAL	ALTHLDA	ADC TEST
5	GOARND (0=on)	PATL DN (0=dn lim)	ADCALTV (0=val)	x		x	GOARD A	WRN HRN
4	MMSNS (1=sensed)	PFLTT (1=test)	ALT VAL (1=val)	x		x	FLTDIRA	TEST UP
3						x	APRARMA	TEST DN
2						x	APRCPLDA	x
1						x	AP ANN	x
0						x		x

x = spare

Note: WDT update = 08400 write

Table 13. Bus Data Buffer Definition

Buffer: AC$VECTOR   Processor ________   Rate: 20 CPS   ID: 1

From: I/O   To: EHSI, NAV, IDCC   #Bytes 11 x30μs + 60μs = 390μs Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	Comments
Buffer Active Flag		0	BUF1$ACT	Logic		B			FF = Active
A/C Heading	ψ	1	PSI	FS=180°		W			
True Airspeed	TAS	3	TAS	FS=2048NM/HR		W			
A/C Roll Attitude	ϕ	5	PHI	FS=180°		W			
Altitude	h	7	BARO$ALT	1'/LSB		W			
VNAV Engage		9	VNAV$ENG	Logic		B			FF = Engaged
DG Valid		10	DG$VALID	Logic		B			FF = Valid

Buffer: AC$STATUS   Processor ________   Rate: 20 CPS   ID: 2
Pointer LOC: C2H

From: I/O   To: EHSI, IDCC   #Bytes 5 x 30μs + 60μs = 540μs Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	Comments
Buffer Active Flag		0	BUF2$ACT	Logic		B			FF Active
% Power		1	PWR	1%/LSB		B			
Selected Heading	h_s	2	SEL$HDG	FS=180°		W			
Radar Altitude	h_r	4	R$ALT	1 /LSB		W			
Total Fuel Flow		6	TFF	FS=256#/hr		W			
Fuel Remaining LBS		8	FUELREMLBS	1#/LSB		W			
A/C Gr. Weight		10	ACGRWGT	1#/LSB		W			
I/O Memory Word		12	IOMEMWORD	Hex		W			
EHSI Fail Sel		14	EHSI$FAIL$SEL	Logic		B			FF = Active

(1) Word/Byte
(2) Generate/use

Table 13. Bus Data Buffer Definition (Continued)

Buffer MAP$CNTR Processor ________ Rate: 10 CPS ID: 3

Pointer LOC: C4

From IDCC To EHSI #Bytes 23 x30us + 60us = 750 Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	Comments
Buffer Active Flag		0	BUF3$ACT	Logic		B			FF = Active
Heading/North Up Flag		1	NO$MODE	Logic		B			FF = North Up (1)
Waypoint Bearing Flag		2	BRG$MODE	Logic		B			FF = Active (1)
Map Review Mode		3	REV$MODE	Logic		B			FF = Active (1)
Scale Select		4	MAP$SCALE	Logic		B			0=40, 1=8, 2=2NMI/IN
MAP/Cursor Slew Mode		5	CUR$MODE	Logic		B			FF = Cursor Mode
MAP Up		6	MAPUPSLEW	64k unit/LSB		W			WRT
MAP Up		8		1 unit/LSB		W			1 Raster Unit = A/C
MAP Right		10	MAP$RIGHT$SLEW	64k unit/LSB		W			1/256 of Screen
MAP Right		12		1 unit/LSB		W			
Cursor Latitude Deg		14		1^o/LSB		W			1^o=60NMI + No
Cursor Latitude Min		16	CURLATLONG	FS=120		W			60 =1 Deg + No WRT ACTIVE WP
Cursor Longitude Deg		18		1^o/LSB		W			1^o=60NMI + West
Cursor Long ude Min		20		FS=120		W			60 =1 Deg + West
EHSI Test Mode Active		22	EHSI$TEST$ACTIVE	Logic		B			FF = Active (1)

(1) Word/Byte

(2) Generate/use

(1) Toggle done in IDCC

Table 13. Bus Data Buffer Definition (Continued)

Buffer NAVAID$DATA$BASE   Processor________   Rate 5 CPS   ID 4

Pointer LOC C6

*From NAV and Flt Plan   To EHSI, IDCC, Bus Cont   #Bytes 221 x 30μs + 60μs = 6690μsec Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	Comments
Buffer Active Flag		0	BUF4$ACT	Logic		B			FF = Active
NAVAID Freq Defined		1	NAVAID$FREQ$DEF	Logic		B			Array of 10 bytes FF=Defined
NAVAID Frequency		11	NAVAID$FREQ	See Note (1)		W			Array of 10 words
NAVAID Variation		31	NAVAID$VAR	FS=180°		W			Array of 10 words + East
NAVAID Elevation		51	NAVAID$ELEV	1'/LSB		W			Array of 10 words
NAVAID ID Defined		71	NAVAIDIDDEF	Logic		B			Array of 10 bytes
NAVAID ID		81	NAVAID$ID	ASCII		3B			Array of 3x10 bytes
NAVAID Lat-Long Defined		111	NAVAIDLATLONG$DEF	Logic		B			Array of 10 bytes FF=Defined
NAVAID Latitude Defined		121	NAVAIDLATDEF	Logic		B			Array of 10 bytes FF=Defined
NAVAID Latitude Deg		131	NAVAID$LAT	1°/LSB		W			60NMI/Deg Array of 2x10
NAVAID Latitude Min				FS=120'		W			60Min/Deg Words
NAVAID Longitude Defined		171	NAVAID$LONG$DEF	Logic		B			Array of 10 bytes
NAVAID Longitude Deg		181	NAVAID$LONG	1°/LSB		W			60NMI/Deg Array of 2x10
NAVAID Longitude Min				FS=120'		W			60NMI/Deg Words

(1) Word/Byte

(2) Generate/use

(1) LSB=50KHZ, Offset=108MHZ

* Sent from Bus Cont to NAV and Flt Plan at IC

Table 13. Bus Data Buffer Definition (Continued)

Buffer WP$DATA$BASE1 Processor ______ Rate: 5 CPS ID 5

Pointer LOC: C8

*From NAV and Flt Plan To EHSI, IDCC, Bus Cont #Bytes 381 x30μs + 60μs = 11490μs Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	Comments
Buffer Active Flag		0	BUF5$ACT	Logic		B			FF=Active
WP Located Flag		1	WP$LOCATED	Logic		B			Array of 10 bytes FF=Located
WP Latitude Deg		11	WPLATLONG	1°/LSB		W			60NMI/Deg — Array of 10x4 words
WP Latitude Min				FS=120		W			60 /Deg
WP Longitude Deg		51		1°/LSB		W			60NMI/Deg
WP Longitude Min				FS=120		W			60 /Deg
WP Linked		91	WP$LINKED	Logic		B			Array of 10 bytes, FF=Linked
WP Course 1 Defined		101	WP$CRS1$DEF	Logic		B			Array of 10 bytes, FF=Defined
WP Course 1		111	WP$CRS1	FS=180°		W			Array of 10 words
WP Course 2 Defined		131	WP$CRS2$DEF	Logic		B			Array of 10 bytes, FF=Defined
WP Course 2		141	WP$CRS2	FS=180°		W			Array of 10 words
WP NAVAID No Defined		161	WPNANO$DEF	Logic		B			Array of 10 bytes, FF=Defined
WP NAVAID Number		171	WPNANO	Integer		B			Array of 10 bytes
WP Blink NAVAID ID		181	WP$BLINK$NA$ID	Logic		B			Array of 10 bytes, FF=Blink
WP NAVAID ID Defined		191	WPNAID$DEF	Logic		B			Array of 10 bytes, FF=Defined
WP NAVAID ID		201	WPNAID	ASCII		3B			Array of 3x10 bytes
WP NAVAID Latitude Deg		231	WPNALAT	1°/LSB		W			60NMI/Deg — Array of 2X10 words
WP NAVAID Latitude Min				FS=120		W			60 /Deg
WP NAVAID Longitude Deg		271	WPNALONG	1°/LSB		W			60NMI/Deg — Array of 2X10 words
WP NAVAID Longitude Min				FS=120		W			60 /Deg
WP Altitude Defined		311	WPALTDEF	Logic		B			Array of 10 bytes
WP Altitude		321	WP$ALT	1 /LSB		W			Array of 10 words
WP VOR/ILS Select		341	WPVORILS$SEL	Logic		B			Array of 10 bytes FF=VOR/ILS
WP MDA/DH Select		351	WPMDADH$SEL	Logic		B			Array of 10 bytes FF=MDA/DH
WP NAVAID Variation		361	WPNANVAR	FS=180°		W			

(1) Word/Byte

(2) Generate/use

*Sent from Bus Cont to NAV and Flight Plan at IC

Table 13. Bus Data Buffer Definition (Continued)

Buffer: WP$DATA$BASE2 Processor ________ Rate: 5 CPS ID: 6

Pointer LOC: CAH

*From: NAV and Flt Plan To: IDCC, Bus Cont #Bytes 111 x30μs + 60μs = 3390μs Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	Comments
Buffer Active Flag		0	BUF6$ACT	Logic		B			FF=Active
WP Offset		1	WP$OFFSET	FS=2048NMI		W			Array of 10 words
WP NAVAID Freq Defined		21	WPNAFREQ$DEF	Logic		B			Array of 10 bytes, FF=Defined
WP NAVAID Frequency		31	WPNAFREQ	See Note (1)		W			Array of 10 words
WP NAVAID Elevation		51	WPNAELEV	1 /LSB		W			Array of 10 words
WP NAVAID Radial		71	WPNARADL	FS=180°		W			Array of 10 words
WP NAVAID Distance		91	WPNADIST	FS=2048NMI		W			Array of 10 words

(1) Word/Byte

(2) Generate/use

(1) LSB=50KHZ, Offset=108MHZ

* Sent from Bus Control to NAV and Flt Plan at IC

Table 13. Bus Data Buffer Definition (Continued)

Buffer: NAV$BUFFER Processor ________ Rate: 5 CPS ID: 7

Pointer LOC: CCH

From: NAV and Flt Plan To: EHSI #Bytes 23 x30µs + 60µs = 750µsec Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	Comments
Buffer Active Flag		0	BUF7$ACT	Logic		B			FF=Active
VOR Mode		1	VOR$MODE	Logic		B			FF=VOR Mode
ILS Mode		2	ILS$MODE	Logic		B			FF=ILS Mode
Time in Dead Reckoning		3	DR$TIME	Integer SEC		W			DR Mode if DR$TIME≠0
Active NAV Receiver Valid		5	NAV$RCVR$VALID	Logic		B			FF=Valid
Active NAV Receiver		6	NAV$RCVR	Integer		B			
Active DME Receiver Valid		7	DME$VALID	Logic		B			FF=Valid
Active DMF Receiver		8	DME$RCVR	Integer		B			
WP Available		9	WP$AVAIL	Integer		B			
A/C Latitude Deg		10		1^{o}/LSB		W			60NMI/Deg
A/C Latitude Min		12	ACLATLONG	FS=120		W			60 /Deg
A/C Longitude Deg		14		1^{o}/LSB		W			60NMI/Deg
A/C Longitude Min		16		FS=120		W			60 /Deg
WP Bearing		18	WP$BRG	FS=180^{o}		W			
Vertical Track Angle		20	VTA	FS=180^{o}		W			
Map Valid for Display		22	MAP$VALID	Logic		B			FF=Valid

(1) Word/Byte

(2) Generate/use

Table 13. Bus Data Buffer Definition (Continued)

Buffer: NAV$STATE Processor ____________ Rate 20 CPS ID: 8

Pointer LOC: CE

From NAV and Flt Plan To EHSI, IDCC, I/O and Flt Cont #Bytes 38 x30μs + 60μs = 1200μs Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	Comments
Buffer Active Flag		0	BUF8$ACT	Logic		B			FF=Active
Active WP Number		1	ACTWPNO	Integer		B			
Active Course Number		2	ACTCRSNO	Integer		B			
Course Datum		3	CRS$DATUM	FS=180°		W			
Course Deviation		5	CRS$DEV	FS=25 dots		W			Scaling Dependent on Mode*
Wind Direction		7	WIND$DIR	FS=180°		W			180° is from South Magnetic
Wind Velocity		9	WIND$VEL	FS=2048NM/HR		W			
Ground Speed		11	GND$SPD	FS=2048NM/HR		W			
VNAV Valid		13	VNAV$VALID	Logic		B			FF=Valid
Back Course Mode		14	BACK$CRS	Logic		B			FF=Back CRS
Vertical Deviation		15	VERT$DEV	1'/LSB		W			
VOR/RNAV/LOC Valid		17	VOR$RNAV$LOC	Logic		B			FF=Valid
ALT Select Valid		18	ALTSELVAL	Logic		B			FF=Valid
RNAV Mode		19	RNAV$MODE	Logic		B			FF=RNAV Mode
RNAV Capture		20	RNAV$CAPT	Logic		B			FF=Capture
Glide Slope Valid		21	GS$VALID	Logic		B			FF=Valid
Distance to Active WP		22	DISTACTWP	FS-1024		W			
Glideslope Deviation		24	FILGSDEV	FS=32°		W			
Altitude Select Deviation		26	ALTSELDEV	1 ft/LSB		W			
VTA Valid		28	VTA$VALID	Logic		B			FF=Valid
NAV Sequence		29	NAV$SEQ	Logic		B			FF=Switch Modes
ILS Valid		30	ILS$VALID	Logic		B			FF=Valid
NAVAID ID Valid		31	NAVIDVALID	Logic		B			FF=Valid
Ground Track		32	GND$TRK	FS=180					
MDA Arm		34	MDA$ARM	Logic		B			FF = Arm
DHArm		35	DH$ARM	Logic		B			FF = Arm
Active WP Alt		36	ACTWPALT	1 /LSB		W			

(1) Word/Byte

(2) Generate/use

*1 dot=1NM RNAV
=2° VOR
=0.5° ILS

Table 13. Bus Data Buffer Definition (Continued)

Buffer NAV$CHG Processor ________ Rate 5 CPS ID 9

Pointer LOC: D0H

From: IDCC To: NAV and Flt Plan #Bytes 10 x30μs + 60μs = 360μsec Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B(1)	Module	G/u(2)	Comments
Buffer Active		0	BUF9$ACT	Logic		B			FF = Active
Destination Buffer No		1	NAV$DEST$BUF	Integer		B			
Input Index		2	NAVININDEX	Integer		B			
Parameter Offset		3	NAV$PARAM$OFST	Integer		W			
Parameter Reset		5	NAV$PARAM$RESET	Logic		B			FF = Reset
Parameter		6	NAV$PARAM	Variable Dependent		4B			4 Byte Array

(1) Word/Byte

(2) Generate/use

Buffer: PERF$CHG Processor ________ Rates: 5 CPS ID: 10

Pointer LOC: D2H

From: IDCC To: I/O and Flt Cont #Bytes 10 x30μs + 60μs = 360μsec Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B(1)	Module	G/u(2)	Comments
Buffer Active		0	BUF10$ACT	Logic		B			FF = Active
Destination Buffer No		1	PERF$DEST$BUF	Integer		B			
Input Index		2	PERFININDEX	Integer		B			
Parameter Offset		3	PERF$PARAM$OFST	Integer		W			
Parameter Reset		5	PERF$PARAM$RESET	Logic		B			FF = Reset
Parameter		6	PERF$PARAM	Variable Dependent		4B			4 Byte Array

(1) Word/Byte

(2) Generate/use

Table 13. Bus Data Buffer Definition (Continued)

Buffer: FLT$WARN   Processor ______   Rate 4 CPS   ID 11

Pointer LOC: D4H

From: I/O and Flt Cont   To: IDCC   #Bytes 34 x 30μs + 60μs = 1080μsec Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	Comments
Buffer Active		0	BUF11$ACT	Logic		B			FF = Active
Message ID		1	WARNMSGID	Integer		B			
Message		2	WARN$MSG	ASCII		32B			32 Byte Array

(1) Word/Byte
(2) Generate/use

Buffer: SYSADVWARN   Processor ______   Rate: 5 CPS   ID: 12

Pointer LOC: D6H

From: NAV and Flt Plan   To: IDCC   #Bytes 20 x30μs + 60μs = 660μs Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	Comments
Buffer Active		0	BUF12$ACT	Logic		B			FF = Active
Message Pending		1	SYSMSGPEND	Logic		B			FF = Message Pending
Message		2	SYS$MSG	ASCII		18B			

(1) Word/Byte
(2) Generate/use

Table 13. Bus Data Buffer Definition (Continued)

Buffer NAV$EDIT Processor ______ Rate: 5 CPS ID 13

Pointer LOC D8H

From NAV and Flt Plan To IDCC #Bytes 16 x30µs + 60us = 540µsec Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	Comments
Buffer Active		0	BUF13$ACT	Logic		B			FF = Active
Start Waypoint		1	START$WP	Integer		B			
End Waypoint		2	END$WP	Integer		B			
Waypoint Generate		3	WP$GEN	Logic		B			FF = Generate
Insert Waypoint Flag		4	INSWPFLG	Logic		B			FF = Insert, WP# in Index (ID4)
Delete Waypoint Flag		5	DELWPFLG	Logic		B			FF = Delete, WP# in Index (ID4)
Use Waypoint Flag		6	USEWPFLG	Logic		B			FF = Use, WP# in Index (ID4)
Course Select Flag		7	CRSSELFLG	Logic		B			FF = Toggle Course
Auto Sequence Flag		8	AUTOSEQFLG	Logic		B			FF = Toggle Mode
Lat-Direct-To Flag		9	LATDIRFLG	Logic		B			FF = Direct to
System Advisory Clear		10	SYSADVCLR$FLG	Logic		B			FF = Clear
Auto Sequence Mode		11	AUTOSEQMODE	Logic		B			FF = Auto Sequence Mode
WP Data Clear Flag		12	WP$DATA$CLR	Logic		B			FF = Clear
NAVAID Data Clear Flag		13	NAV$DATA$CLR	Logic		B			FF = Clear
Copy Active WP		14	CPYACTWP	Logic		B			FF = Copy (Display WP in Index)
WP Present Position Flag		15	WP$PRES$POS	Logic		B			FF = Copy (To Designated WP)

(1) Word/Byte

(2) Generate/use

Buffer PERF$EDIT Processor ______ Rate: 5 CPS ID: 14

Pointer LOC: DAH

From: I/O and Flt Cont To: IDCC #Bytes 10 x30µs + 60µs = 360µsec Tranfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	Comments
Buffer Active		0	BUF14$ACT	Logic		B			FF = Active
Initial Gr. Wgt. Defined		1	INITGRWGT$DEF	Logic		B			
Initial Gr. Weight		2	INITGRWGT	1#/LSB		W			
Initial Fuel Defined		4	INIT$FUEL$DEF	Logic		B			FF = Defined
Initial Fuel Load		5	INIT$FUEL$LD	1#/LSB		W			
System Test Mode		7	SYSTSTMODE	Logic		B			FF = Test Mode
Message Acknowledge Mode		8	MSGACKMODE	Logic		B			FF = Remove Message
Signal Stim Measure Mode		9	SIGTSTMODE	Logic		B			FF = Test Mode

(1) Word/Byte

(2) Generate/use

Table 13. Bus Data Buffer Definition (Continued)

Buffer. WT$BALANCE Processor ______ Rate: 5 CPS ID: 15

Pointer LOC: DCH

From: ID and Flt Cont To: IDCC #Bytes 33 x 30μs + 60μs = 1050μsec Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	Comments
Buffer Active		0	BUF$ACT	Logic		B			FP = Active
Seat 1 & 2 Weight		1	SEAT 1$2	1#/LSB		W			
Seat 3 & 4 Weight		3	SEAT 3$4	1#/LSB		W			
Seat 5 & 6 Weight		5	SEAT 5$6	1#/LSB		W			
Avionics Bay Weight		7	AV$BAY	1#/LSB		W			
Nose Bay Weight		9	NOSE$BAY	1#/LSB		W			
AFT Cabin Weight		11	AFT$CABIN	1#/LSB		W			
Wing Locker Weight		13	WING$LOCK	1#/LSB		W			
Other Weight		15	OTHER$WGT	1#/LSB		W			
Distance Behind Seat 1		17	DIST$SEAT$1	1#/LSB		W			
Main Fuel Weight		19	MAIN$FUEL	1#/LSB		W			
Aux Fuel Weight		21	AUX$FUEL	1#/LSB		W			
Takeoff Fuel		23	TO$FUEL	1#/LSB		W			
Takeoff Weight		25	TOACWGT	1#/LSB		W			
CG Position		27	CG$POS	1#/LSB		W			
Forward CG Position		30	FWD$CG	1#/LSB		W			
AFT CG Position		32	AFT$CG	1#/LSB		W			

(1) Word/Byte

(2) Generate/use

Table 13. Bus Data Buffer Definition (Continued)

Buffer PERF (Sheet 1 of 2) Processor________ Rate 5 CPS ID 16

Pointer LOC: DEM

From: I/O and Flt Cont To: IDCC #Bytes 72 x30μs + 60μs = 2220 μsec Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	Comments
Buffer Active		0	BUF16$ACT	Logic		B			FF = Active
T.O. Perf Auto Entry		1	TO$AUTO$ENT	Logic		B			FF = Auto Entry Mode
T.O. Altitude		2	TO$ALT	1'/LSB		W			
T.O. Baro Set Defined		4	TO$BARO$DEF	Logic		B			FF = Defined
T.O. Baro Setting		5	TO$BARO$SET	FS=256"		W			
T.O. Wind Direction		7	TO$WIND$DIR	FS=180°		W			
T.O. Wind Magnitude		9	TO$WIND$MAG	FS=2048Km/Hr		W			
T.O. Outside Air Temp Defined		11	TOOATDEF	Logic		B			FF = Defined
T.O. Outside Air Temp		12	TO$OAT	1°C/LSB		W			
T.O. A/C Weight Defined		14	TOWGTDEF	Logic		B			FF = Defined
T.O. A/C Weight		15	TO$WGT	1#/LSB		W			
Runway Heading		17	RNWAY$HDG	FS=180°		W			
Accel Go Dist		19	GO$DIST	1'/LSB		W			
Takeoff 50' Speed		21	TO50SPEED	FS=2048Km/Hr		W			
Ground Roll		23	GRND$ROLL	1'/LSB		W			
A/C Stop Distance		25	STOP$DIST	1'/LSB		W			
Best Rate of Climb Speed		27	BESTROCSPD	FS=2048Km/Hr		W			
Best Rate of Climb		29	BEST$ROC	FS=2048Ft/Min		W			
Best Angle Speed		31	BESTANGSPD	FS=2048Km/Hr		W			
Distance to 50 Feet		33	DIST50FT	1'/LSB		W			
Cruise Perf Auto Entry		35	CR$AUTO$ENT	Logic		B			FF = Auto Entry Mode
Cruise Altitude		36	CR$ALT	1'/LSB		W			
Cruise Baro Set Defined		38	CR$BARO$DEF	Logic		B			FF = Defined
Cruise Baro Setting		39	CR$BARO$SET	FS=256"		W			
Cruise Wind Direction		41	CR$WIND$DIR	FS=180°		W			

(1) Word/Byte

(2) Generate/use

Table 13. Bus Data Buffer Definition (Continued)

Buffer: PERF (Sheet 2 of 2) Processor: ____________ Rate: 5 CPS ID: 16

Pointer LOC: DEH

From: I/O and Flt Cont To: IDCC #Bytes 71 x30μs + 60μs = 2190μsec Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	Comments
Cr. Wind Magnitude		43	CR$WIND$MAG	FS=2048NM/Hr		W			
Cr. OAT Defined		45	CROATDEF	Logic		B			FF = Defined
Cr. Outside Air Temp		46	CR$OAT	1^{o}C/LSB		W			
Cr. A/C Weight Defined		48	CRWGTDEF	Logic		B			FF = Defined
Cr. A/C Weight		49	CR$WGT	1#/LSB		W			
Cr. Segment Distance		51	CR$DIST	FS=2048NM/Hr		W			
Cr. Perf TAS		53	CR$TAS	FS=2048NM/Hr		W			
Cr. Perf Ground Speed		55	CRGNDSPD	FS=2048NM/Hr		W			
Cr. Perf % Power		57	CR$PWR	1%/LSB		B			
Cr. Manifold Pressure		58	CR$MAP	FS=2048"		W			
Cr. RPM		60	CR$RPM	1RPM/LSB		W			
Cr. Fuel Rate		62	CR$FUEL$RATE	FS=256#/Hr		W			
Cr. NM/LB Fuel		64	CR$MILE$LBS	FS=128NM/Hr		W			
Cr. ETA in Min		66	CR$ETE	1Min/LSB		W			
Cr. Fuel Required		68	CR$FUEL$REQ	1#/LSB		W			
Cr. Course		70	CR$COURSE	180^{o} FS		W			

(1) Word/Byte

(2) Generate/use

Table 13. Bus Data Buffer Definition (Continued)

Buffer DABS   Processor ________   Rate: 5 CPS   ID: 17

Pointer LOC EØH

From DABS   To: IDCC   #Bytes 56 x 30μs + 60μs = 1740μsec Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B(1)	Module	G/u(2)	Comments
Buffer Active		0	BUF17$ACT	Logic		B			FF = Active
DABS Acknowledge		1	DABS$ACK	Logic		B			FF = Acknowledge
DABS Send		2	DABS$SEND	Logic		B			FF = Send
DABS Clear		3	DABS$CLR	Logic		B			FF = Clear
Surface Location		4	SUR$LOC	ASC II		3B			
Terminal Location		7	TERM$LOC	ASC II		3B			
Terminal GMT		10	TERM$GMT	1 hr/LSB		B			
Pilot Reports Location		11	REPTS$LOC	ASC II		3B			
Pilot Reports GMT		14	REPTS$GMT	1 hr/LSB		B			
Wind Reports Location		15	WND$LOC	ASC II		3B			
Wind Reports GMT		18	WND$GMT	1 hr/LSB		B			
Wind Altitude		19	WND$ALT	1k ft/LSB		B			
Down Link Msg Pointer		20	DN$LINK$PTR	Integer		B			0=NONE,1=SUR,2=TERM,3=RPT,4=WND
DABS Memory Word		21	DABSMEMWORD	Hex		W			
Message Line Number		23	MSG$LINE$NO	Integer		B			0=8 ≡ Line 1-9
DABS Message Line		24	DABSMSGLINE	ASC II		32B			

(1) Word/Byte

(2) Generate/use

Buffer: DABS$CHG   Processor ________   Rate: 5 CPS   ID: 18

Pointer LOC: E2H

From: IDCC   To: DABS   #Bytes 10 x30μs + 60μs = 360μsec Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B(1)	Module	G/u(2)	Comments
Buffer Active		0	BUF18$ACT			B			FF = Active
Destination Buffer No		1	DABS$DEST$BUF			B			
Input Index		2	DABSININDEX			B			
Parameter Offset		3	DABS$PARAM$OFST			W			
Parameter Reset		5	DABS$PARAM$RESET			B			FF = Reset
Parameter		6	DABS$PARAM			4B			4 Byte Array

(1) Word/Byte

(2) Generate/use

Table 13. Bus Data Buffer Definition (Continued)

Buffer: SIG$MEAS   Processor ________   Rate: ___ CPS   ID: 19

Pointer LOC: E4

From: IO and Flt Cont   To: IDCC   #Bytes 14 x30μs + 60μs = 360μsec Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	Comments
Buffer Active Flag		0	BUF19$ACT	Logic		B			FF = Active
Signal Measure Test Active		1	SIG$MEAS$ACT	Logic		B			FF = Active
Analog Measure Address		2	DCINADR			B			
Analog Input Volts		3	DCINVOLTS			W			
Analog Output Address		5	DCOUTADR			B			
Analog Output Value		6	DCOUTVAL			W			
Discrete Measure Address		8	DISCINADR			B			
Discrete Input Word		9	DISCINWORD			W			
Discrete Output Address		11	DISCOUTADR			B			
Discrete Output Value		12	DISCOUTVAL			W			

(1) Word/Byte

(2) Generate/use

Buffer: BUS$CONT$STATUS   Processor   Rate: CPS   ID: 20

Pointer LOC: E6

From: Bus Cont   To: IDCC   #Bytes 5 x30μs + 60μs = 210μsec Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	Comments
Buffer Active Flag		0	BUF20$ACT	Logic		B			FF = Active
Bus Memory Word		1	BUSMEMWORD	Hex		W			
Fail Clear Response		3	FAILCLRRESP	Logic		B			FF = Active
Bus Test Bus		4	BUSTSTBUS	Logic		B			All Ones

(1) Word/Byte

(2) Generate/use

Table 13. Bus Data Buffer Definition (Continued)

Buffer: IO$VALID   Processor ______   Rate: ___CPS   ID: 21

Pointer LOC: E8

From: IO and Flt Cont   To: Bus Cont   #Bytes 5 x30µs + 60µs = 210µsec Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	$W/B^{(1)}$	Module	$G/u^{(2)}$	Comments
Buffer Active		0	BUF21$ACT	Logic	0030H	B			FF = Active
Valid Word		1	IO$VAL	Logic	0031H	W			See Bit Disc for Format
Sim EHSI Fail		3	SIM$EHSI$ FAIL	Logic		B			
Bus Test I/O		4	BUSTSTIO	Logic					All Ones

(1) Word/Byte

(2) Generate/use

Buffer: NAV$VAL   Processor ______   Rate: ___CPS   ID: 22

Pointer LOC: EAH

From: NAV and Flt Plan   To: Bus Cont, IO and Flt Cont $Bytes 6 x 30µs + 60µs = 240µsec Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	$W/B^{(1)}$	Module	$G/u^{(2)}$	
Buffer Active		0	BUF22$ACT	Logic	0030H	B			FF = Active
Valid Word		1	NAV$VALID	Logic	0031H	W			See BIT Disc. for Format
NAV Memory Word		3	NAVMEMWORD	Hex		W			
Bus Test NAV		5	BUSTSTNAV	Logic		B			All Ones

(1) Word/Byte

(2) Generate/use

Table 13. Bus Data Buffer Definition (Continued)

Buffer: IDCC$VAL Processor__________ Rate:___ CPS ID: 23

Pointer LOC: ECH

From: IDCC To: Bus Cont, IO and Flt Cont #Bytes 4 x30μs + 60μs = 180μsec Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	
Buffer Active		0	BUF23$ACT	Logic	0030H	B			FF = Active
Valid Word		1	IDCC$VALID	Logic	0031H	W			See BIT Disc for Format
Bus Test IDCC		3	BUSTST IDCC	Logic		B			All Ones

(1) Word/Byte

(2) Generate/use

Buffer: EHSI$VAL Processor__________ Rate: 5 CPS ID: 24

Pointer LOC: EEH

From: EHSI To: Bus Cont, IO and FLT Cont $Bytes 6 x 30μs + 60μs = 240μsec Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	
Buffer Active		0	BUF24$ACT	Logic	0030H	B			FF = Active
Valid Word		1	EHSI$VALID	Logic	0031H	W			See BIT Disc for Format
EHSI Memory Word		3	EHSIMEMWORD	Hex		W			
Bus Test EHSI		5	BUSTSTEHSI	Logic		B			All Ones

(1) Word/Byte

(2) Generate/use

Table 13. Bus Data Buffer Definition (Continued)

Buffer: RAU$VAL   Processor________   Rate: ___CPS   ID: 25

Pointer LOC: FD

From: NAV and Flt Plan   To: Bus Cont, IO and Flt Cont   #Bytes 3 x30μs + 60μs = 150μsec Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	Comments
Buffer Active		0	BUF25$ACT	Logic		B			FF = Active
Valid Word		1	RAU$VALID	Logic		W			See BIT Disc for Format

(1) Word/Byte

(2) Generate/use

Buffer: SPARE$VAL   Processor__________   Rate: ___ CPS   ID: 26

Pointer LOC: F2H

From: Spare   To: Bus Cont and Flt Cont   #Bytes 6 x30μs + 60μs = 240μsec Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	Comments
Buffer Active		0	BUF26$ACT	Logic	0030H	B			FF = Active
Valid Word		1	SPARE$VALID	Logic	0031H	W			See BIT Disc for Format
Spare Memory Word		3	SPAREMEM WORD	Hex		W			
Bus Test Spare		5	BUSTST SPARE	Logic		B			All Ones

(1) Word/Byte

(2) Generate/use

Table 13. Bus Data Buffer Definition (Continued)

Buffer: DABS$VAL Processor____________ Rate:___CPS ID: 27

Pointer LOC: F4

From: DABS To: Bus Cont and Flt Cont #Bytes 4 x 30μs + 60μs = 180μsec Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	Comments
Buffer Active		0	BUF27$ACT	Logic	0030H	B			FF = Active
Valid Word		1	DABS$VALID	Logic	0031H	W			See BIT Disc for Format
Bus Test Dabs		3	BUSTST DABS	Logic		B			All Ones

(1) Word/Byte

(2) Generate/use

Buffer: BUS$CONT$VAL Processor________ Rate:___CPS ID: 28

Pointer LOC: F6

From: Bus Cont To IO and Flt Cont #Bytes 3 x30μs + 60μs = 150μsec Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	Comments
Buffer Active		0	BUF28$ACT	Logic		B			FF = Active
Valid Word		1	BUS$CONT$VALID	Logic		W			See BIT Disc for Format

(1) Word/Byte

(2) Generate/use

Table 13. Bus Data Buffer Definition (Continued)

Buffer: TIME   Processor ________   Rate: 5 CPS   ID: 29

Pointer LOC: F8H

*From: IDCC   To: Bus Cont   #Bytes 5 x30µs + 60µs = 210µsec Transfer Time

Variable	Sym	Seq	Name	Scale	MEM	LOC	W/B (1)	Module	G/u (2)	Comments
Buffer Active		0	BUF29$ACT	Logic			B			FF = Active
Time Gmt Hrs		1	GMT$HRS	1Hr/LSB			B			
Time Gmt Min		2	GMT$MIN	1Min/LSB			B			
Time Gmt Sec		3	GMT$SEC	1Sec/LSB			B			
Fail Record Clr		4	FAILRECCLR	Logic			B			FF = Clear

(1) Word/Byte

(2) Generate/use

Table 11. Bus Data Buffer Definition (Continued)

Buffer: RADIO DATA   Processor__________   Rate: 20 CPS   ID: 30

Pointer LOC:

From: RAU   To: NAV and Flt Plan   #Bytes 30 x30μs + 60μs = 960μsec Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	Comments
RAU Status Word		0	RAU$STATUS	See Attachment		W			
NAV1 VOR/LOC		2	NAV1VORLOC			W			
NAV1 GS		4	NAV1$GS			W			
NAV1 Freq		6	NAV1$FREQ			B			
NAV1 Ident		7	NAV1$IDENT			3B			
NAV2 VOR/LOC		10	NAV2VORLOC			W			
NAV2 GS		12	NAV2$GS			W			
NAV2 Freq		14	NAV2$FREQ			B			
NAV2 Ident		15	NAV2$IDENT			3B			
DME Range		18	DME$RANGE			W			
DME Freq		20	DME$FREQ			B			
DME Ident		21	DME$IDENT			3B			
COM1 Freq		24	COM1$FREQ			W			
COM2 Freq		26	COM2$FREQ			W			
Switch Status		28	RAUSWSTATUS			B			
Spare		29	RAU$SPARE						

(1) Word/Byte
(2) Generate/use
MSB=BIT 15

Table 13. Bus Data Buffer Definition (Continued)

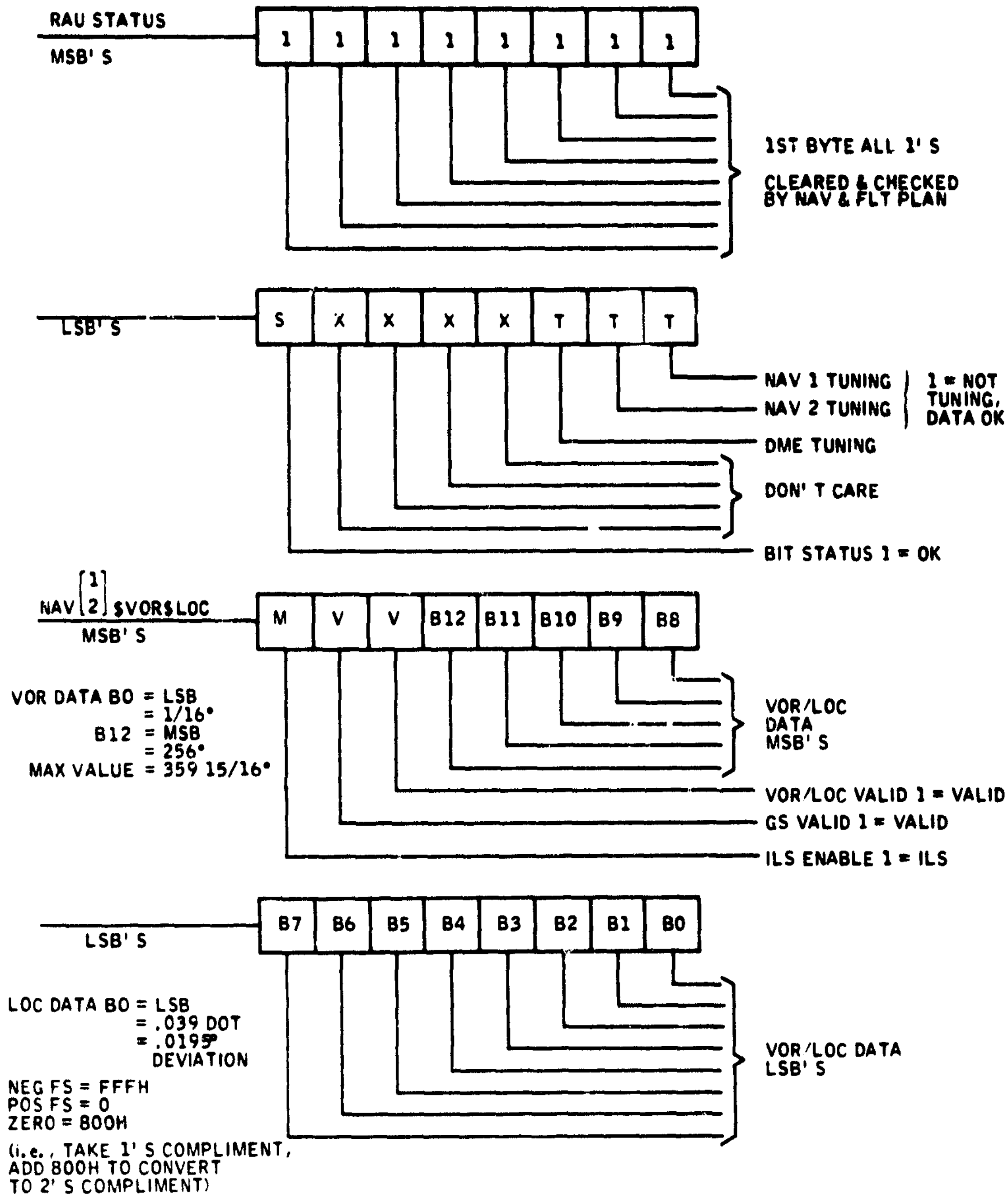


Table 13. Bus Data Buffer Definition (Continued)

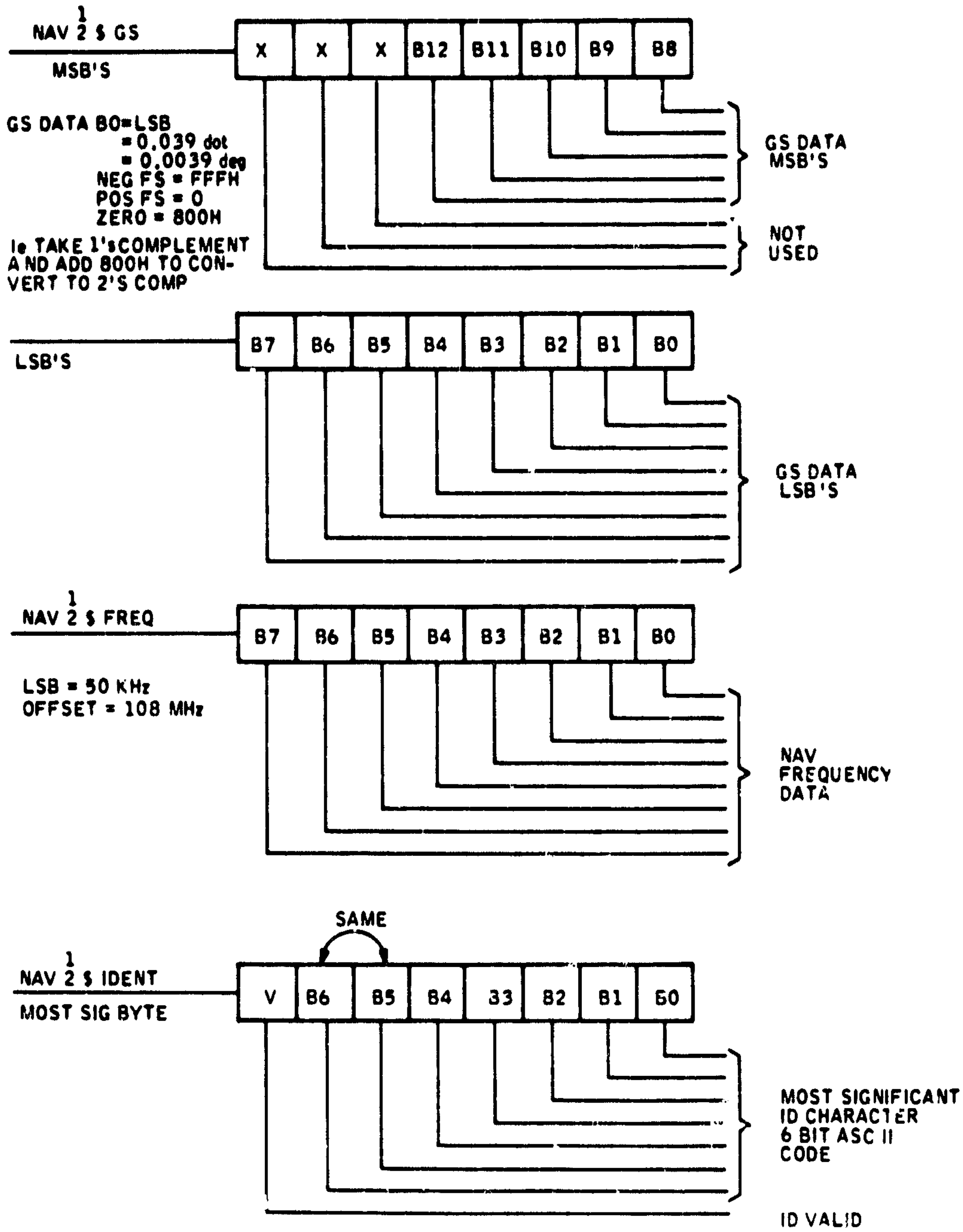


Table 13. Bus Data Buffer Definition (Continued)

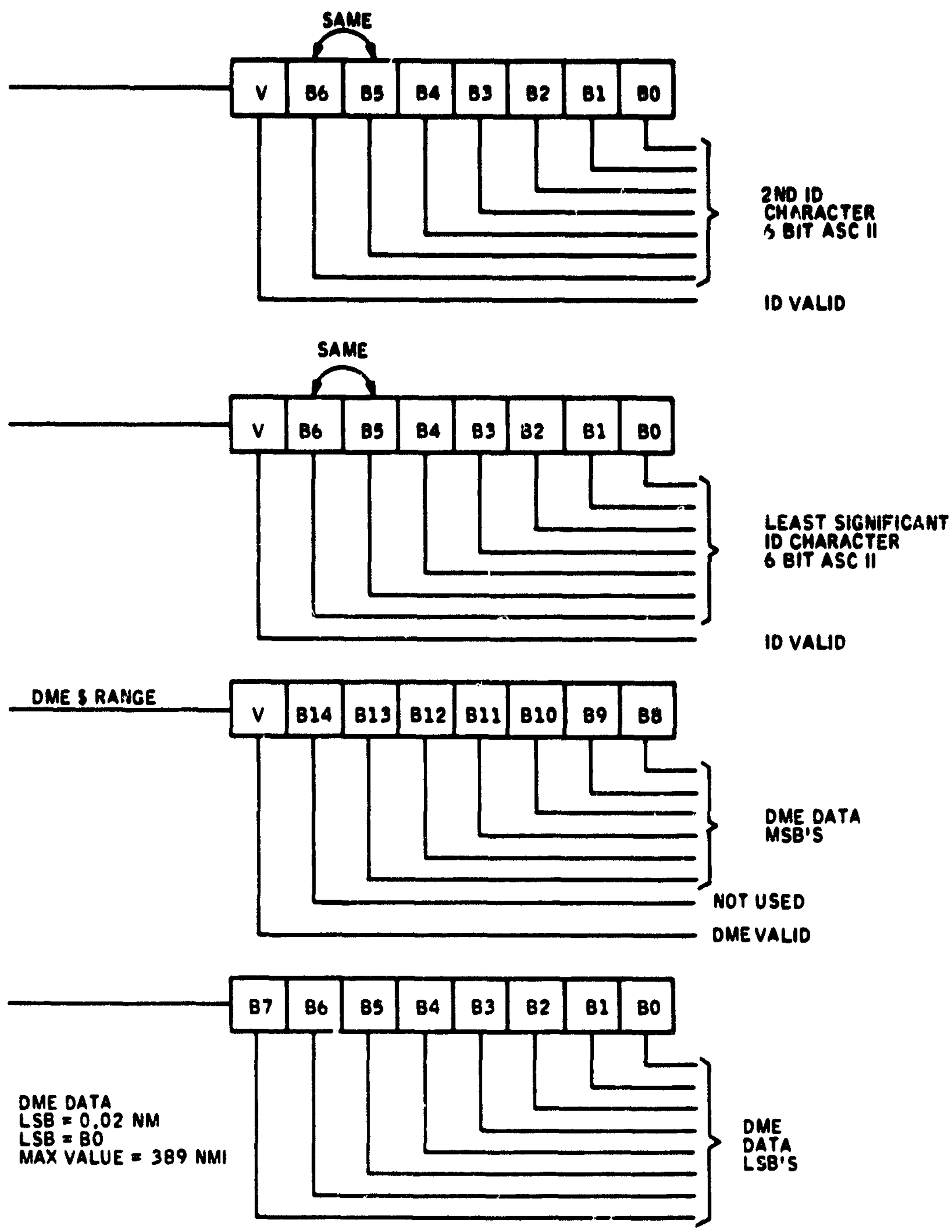


Table 13. Bus Data Buffer Definition (Continued)

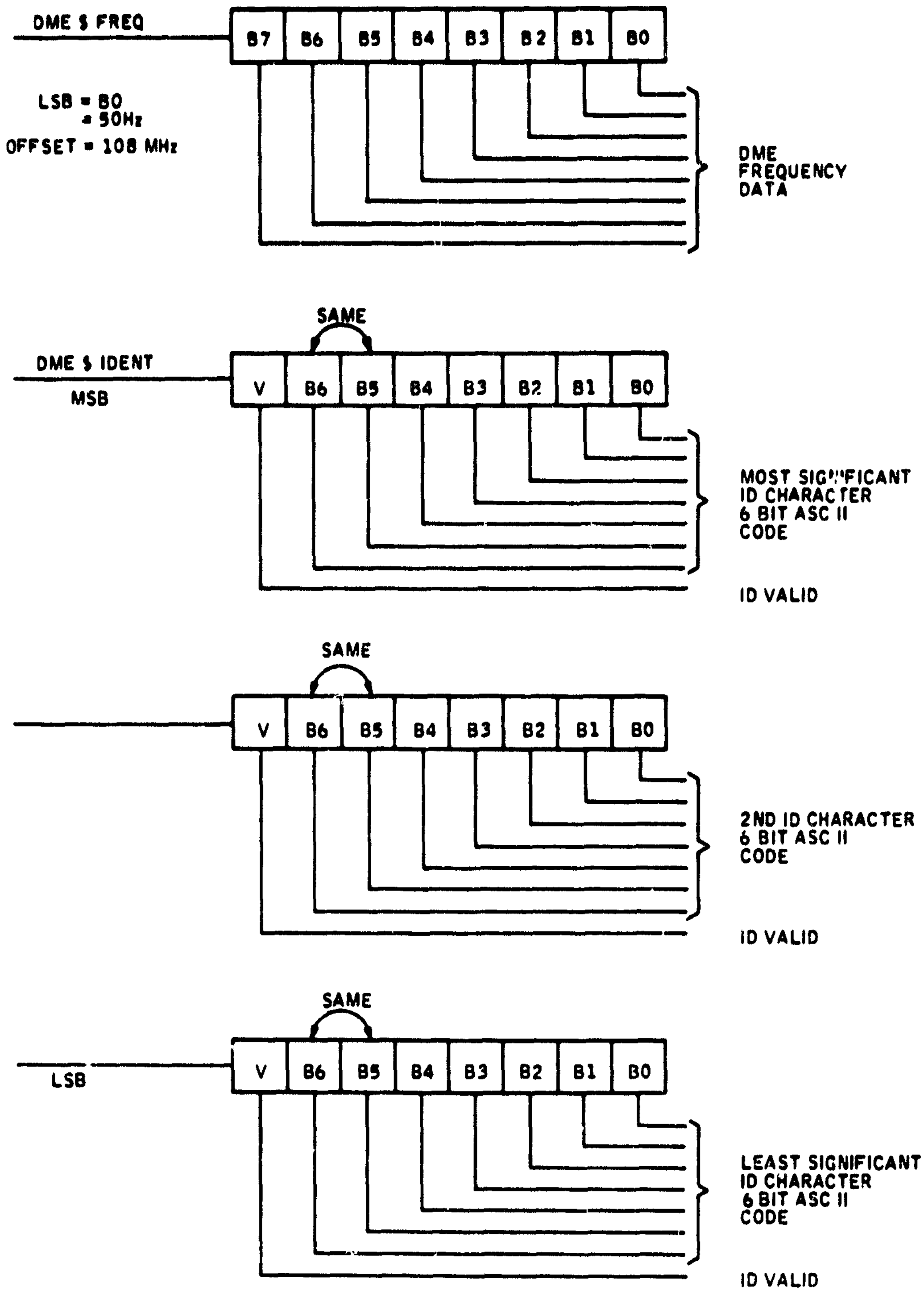


Table 13. Bus Data Buffer Definition (Continued)

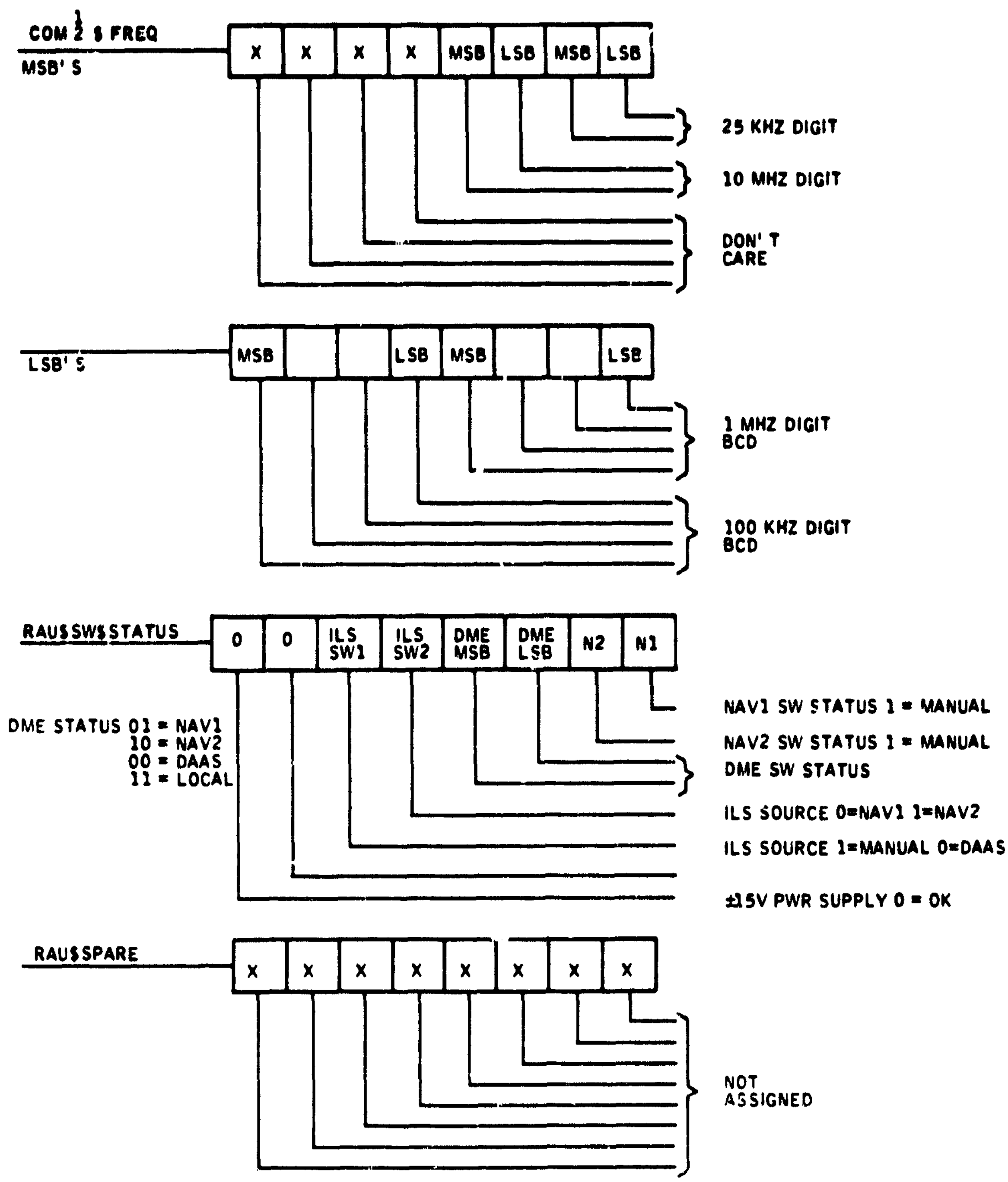


Table 13. Bus Data Buffer Definition (Continued)

Buffer: TUNE$CMDS Processor ________ Rate: 20 CPS ID: 31

Pointer LOC: FE

From: NAV and Flt Plan To: RAU

#Bytes 2 x30μs + 60μs = 120μsec Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	Comments
RAU Command Word		0	RAU$ COMMAND$ WORD	See Attachment		W			

(1) Word/Byte

(2) Generate/use

C-3

Table 13. Bus Data Buffer Definition (Continued)

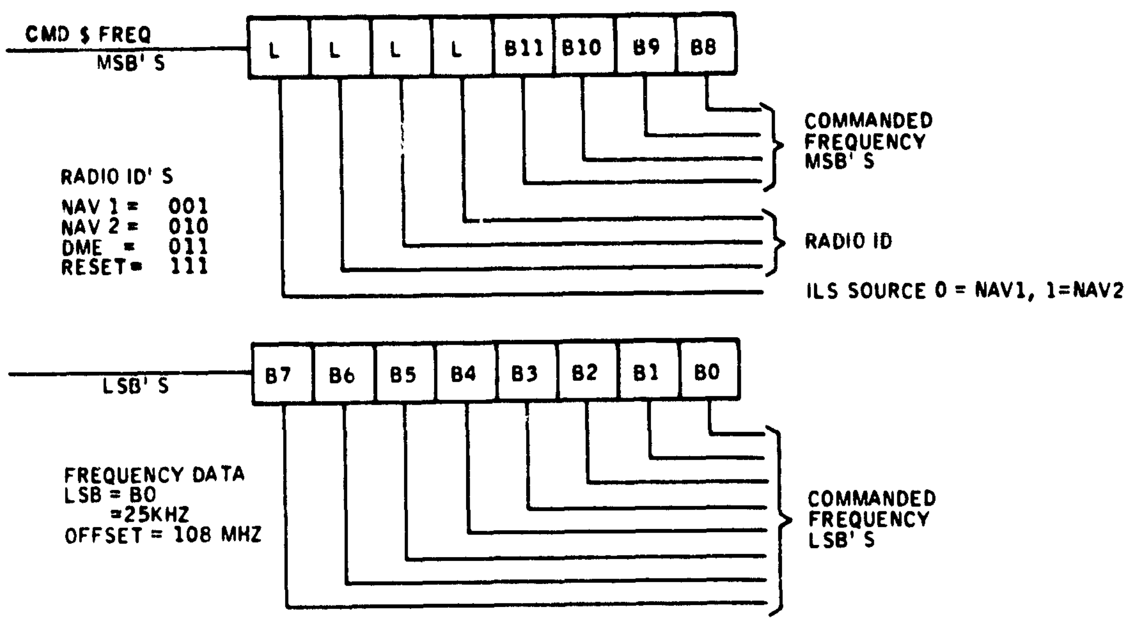


Table 13. Bus Data Buffer Definition (Continued)

Buffer: DABS$CONT   Processor ______   Rate: 5 CPS   ID: 32

Pointer LOC:

From: DABS   To: IO and Flt Cont   #Bytes 3 x30μs + 60μs = 150μsec Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	Comments
Buffer Active		0	BUF32$ACT	Logic		B			FF = Active
DABS LT. Command		1	DABS$LT	Logic		B			FF = Light
DABS Horn Command		2	DABS$HORN	Logic		B			FF = Horn

(1) Word/Byte

(2) Generate/use

Table 13. Bus Data Buffer Definition (Concluded)

Buffer: MEM$MONITOR   Processor ____________   Rate: 5 CPS   ID: 33

Pointer LOC:

From: IDCC   To: All Except RAU   #Bytes 13 x 30μs + 60μs = 450μsec Transfer Time

Variable	Sym	Seq	Name	Scale	MEM LOC	W/B (1)	Module	G/u (2)	Comments
Buffer Active Flag		0	BUF33$ACT	Logic		B			FF = Active
Bus Controler Adr.		1	BUS$ADR	Integer		W			
NAV Adr.		3	NAV$ADR	Integer		W			
Spare Adr		5	SPARE$ADR	Integer		W			
EHSI Adr.		7	EHSI$ADR	Integer		W			
I/O Adr.		9	IO$ADR	Integer		W			
DABS Adr		11	DABS$ADR	Integer		W			

Section 8.0
Support Equipment

The development support equipment to be used during the system development and flight test phase consists of the following items:

- MDS 230 Microcomputer Development System
- MDS 311 PL/M86 compiler and assembler software package
- MDS 201 Expansion chassis for MDS 230 to accommodate the ICE 86
- ICE 86 In-circuit Emulator

The MDS 230 is the development system hardware that consists of a CPU, 64K bytes of RAM, 4K bytes of ROM, a 2000-character CRT, full ASCII keyboard, and dual double density diskette drives.

The MDS-311 is the software package that includes the compiler (PL/M-86) and assembler that operates on MDS-230. It also includes the linker and location software.

The MDS-201 is additional hardware that is required to allow the MDS 230 to handle the in-circuit emulator. The MDS-201 is needed to supply both card space and power for the in-circuit emulator.

The ICE-86 is the in-circuit emulator that allows monitoring of the program operation in the actual hardware. The ICE-86 is used to debug system software and hardware.